B. Tech.

IN

ELECTRONICS AND COMMUNICATION ENGINEERING

FLEXIBLE CURRICULUM

(For students admitted in 2022-23)

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY

TIRUCHIRAPPALLI – 620 015

TAMIL NADU, INDIA

Institute Vision and Mission

Vision

- To be a university globally trusted for technical excellence where learning and research integrate to sustain society and industry.

Mission

- To offer undergraduate, postgraduate, doctoral and modular programmes in multi-disciplinary / inter-disciplinary and emerging areas.
- To create a converging learning environment to serve a dynamically evolving society.
- To promote innovation for sustainable solutions by forging global collaborations with academia and industry in cutting-edge research.
- To be an intellectual ecosystem where human capabilities can develop holistically.

Department Vision and Mission

Vision

- To excel in education and research in Electronics and Communication Engineering

Mission

- To educate with the state of art technologies to meet the growing challenges of the industry.
- To carry out research through constant interaction with research organizations and industry.
- To equip the students with strong foundations to enable them for continuing Education.

Program Educational Objectives (PEOs)

- **PEO1:** Our Graduates would be successful in Technical and Professional careers
- **PEO2:** Our Graduates would be successful in their post-undergraduate studies at leading Institutions.

Program Outcomes (POs)

Graduates of the Electronics and Communication Engineering programme will have the ability

- **PO1:** To apply the knowledge on Mathematics, Science, and Engineering concepts in Complex Engineering problems.

- **PO2:** To analyze the complex engineering problems by using the first principles of Mathematics and Engineering fundamentals.

- **PO3:** To design a component, a system or process to meet the specific needs within realistic constraints such as economics, environment, ethics, health, safety and manufacturability.

- **PO4:** To perform investigations, design as well as conduct experiments, analyze and interpret the results to provide valid conclusions.

- **PO5:** To select and apply appropriate techniques for the design & analysis of systems using modern CAD tools.

- **PO6:** To offer engineering solutions to societal problems**.**

- **PO7:** To understand that the solutions have to be provided taking the environmental issues and sustainability into consideration**.**

- **PO8:** To understand professional responsibilities and Ethics.

- **PO9:** To function effectively either as a member or a leader in multidisciplinary activities.

- **PO10:** To communicate effectively to both the peers and the others and give as well receive clear instructions.

- **PO11:** To apply engineering & management principles in their own / team projects in a multidisciplinary environment**.**

- **PO12:** Realize the need for lifelong learning and engage them to adopt technological changes.

B.Tech. Curriculum Structure for the Students admitted during the academic year 2022 – 2023: The total minimum credits for completing the B.Tech. programme in Electronics and Communication Engineering is 158.

Semester I (July Session)

CODE	COURSE	Credits	Category
ENIR11	Energy and Environmental Engineering	2	GIR
MAIR12	Linear Algebra and Calculus (Mathematics I)	3	GIR
PHIR11	Physics (Circuit)	3	GIR
PHIR12	Physics Lab (Circuit)	2	GIR
CSIR11	Introduction to Computer Programming (Theory & lab) (**Circuit**)	3	GIR
MEIR11	Basics of Mechanical Engineering (For CE, EE,EC, IC & CS)	2	GIR
PRIR11	Engineering Practice	2	GIR
CEIR11	Basics of Civil Engineering (For EE, EC, IC & CS)	2	GIR
	Total	**19**	

Semester II (January Session)

CODE	COURSE	Credits	Category
HSIR11	English for Communication (Theory and Lab)	4	GIR
MAIR22	Complex Analysis and Differential Equations (Mathematics II)	3	GIR
CHIR11	Chemistry (Circuit)	3	GIR
CHIR12	Chemistry Lab (Circuit)	2	GIR
ECIR15	Introduction to Electronics and communication Engineering	2	GIR
MEIR12	Engineering Graphics	3	GIR
ECPC13	Semiconductor Physics and Devices	4	PC
SWIR11	NSS / NCC / NSO	0	GIRCC
	Total	**21**	

Semester III (July Session)

CODE	COURSE	Credits	Category
MAIR33	Real Analysis and Probability Theory (Mathematics III)	4	GIR
ECPC10	Signals and Systems	4	PC
ECPC11	Network Analysis and Synthesis	4	PC
ECPC12	Electrodynamics and Electromagnetic Waves	4	PC
ECPC14	Digital Circuits and Systems	3	PC
ECLR10	Devices and Networks Laboratory	2	ELR
ECLR11	Digital Electronics Laboratory	2	ELR
	Elective – I	3	PE/OE
	Total	**26**	

Note: Department to offer Minor (MI) Course, and ONLINE Course (OC) to those willing students in addition to 26 credits.

Semester IV (January Session)

CODE	COURSE	Credits	Category
HSIR13	Industrial Economics and Foreign Trades	3	GIR
ECPC15	Digital Signal Processing	4	PC
ECPC16	Transmission Lines and Waveguides	3	PC
ECPC17	Electronic Circuits	3	PC
ECLR12	Electronic Circuits Laboratory	2	ELR
ECLR13	Microprocessor and Microcontroller Laboratory	2	ELR
	Elective – II	3	PE/OE
	Elective – III	3	PE/OE
	Total	**23**	

Note: Department to offer Minor (MI) Course, and ONLINE Course (OC) to those willing students in addition to 23 credits.

Semester V (July Session)

CODE	COURSE	Credits	Category
ECPC18	Analog Communication	3	PC
ECPC19	Digital Communication	3	PC
ECPC20	Antennas and Propagation	3	PC
ECPC21	Analog Integrated Circuits	3	PC
ECLR14	Analog VLSI & Embedded System Design Laboratory	2	ELR
ECLR15	Digital Signal Processing Laboratory	2	ELR
	Elective – IV	3	PE/OE
	Elective – V	3	PE/OE
	Total	**22**	

Note: Department to offer Minor (MI) Course, and ONLINE Course (OC) to those willing students in addition to 22 credits.

Semester VI (January Session)

CODE	COURSE	Credits	Category
ECIR19	Industrial Lecture	1	GIR
ECPC22	Wireless Communication	3	PC
ECPC23	VLSI Systems	3	PC
ECPC24	RF and Microwave Engineering	3	PC
ECLR16	Communication Engineering Laboratory	2	ELR
ECLR17	Microwave & Fiber Optic Laboratory	2	ELR
HSIR14	Professional Ethics (Circuit)	3	GIR
	Elective - VI	3	PE/OE
	Elective - VII	3	PE/OE
	Total	**23**	

Note: Department to offer Minor (MI) Course, and ONLINE Course (OC) to those willing students in addition to 23 credits.

Semester VII (July Session)

CODE	COURSE	Credits	Category
ECIR16	Summer Internship	2	GIR
	Elective – VIII	3	PE/OE
	Elective – IX	3	PE/OE
	Elective – X	3	PE/OE
	Elective – XI	3	PE/OE
	TOTAL	**14**	

Note: Department to offer Minor (MI) Course, and ONLINE Course (OC) to those willing students in addition to 14 credits.

Semester VIII (January Session)

CODE	COURSE	Credits	Category
ECIR18	Comprehensive Viva Voce	1	GIR
ECIR17	Project Work$/ Equivalent no. of Electives	**6**	**Optional**
	Elective – XII	3	PE/OE
	Elective – XIII	3	PE/OE
	Elective – XIV	3	PE/OE
	TOTAL	**10**	

Note: Department to offer Minor (MI) Course, and ONLINE Course (OC) to those willing students in addition to 10 credits.

$Optional course

Credit Distribution

Semester	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**Total**
Credit	**19**	**21**	**26**	**23**	**22**	**23**	**14**	**10**	**158**

Note:

1. Minimum of 4 programme core courses shall be 4 credits each.
2. Out of 14 elective courses (PE/OE), the students should study **at least eight programme elective courses (PE).**
3. MI – Minor Degree: **15 credits over and above** the minimum credit as specified by the departments. The details of MINOR will be mentioned only in the transcript not in the Degree certificate.
4. HO – Honours Degree: **15 credits over and above** the minimum credit as specified by the departments. The project work is compulsory.

Course Structure:

Course Category	Courses	No. of Credits	Weightage (%)
GIR (General Institute Requirement Courses)	22	50	31.25
PC (Programme Core)	15	49 – 55**	32.50
Programme Electives (PE) / Open Electives (OE)	14$	42	26.25
Essential Laboratory Requirements (ELR)	Maximum 2 per session up to 6th semester	16	10
Total		**160 ±3**	**100**
Minor (Optional)	Courses for 15 credits	15 Additional credits	-
Honours (Optional)	Courses for 15 credits	15 Additional credits	-

**Minimum of 4 programme core courses shall be 4 credits each

$Out of 14 elective courses (PE/OE), the students should study at least eight programme elective courses (PE)

General Institute Requirements(GIR):

Sl. No.	Name of the course	Number of courses	Max. Credits
1.	Mathematics	3	10
2.	Physics	1 Theory	3
		1 Lab	2
3.	Chemistry	1 Theory	3
		1 Lab	2
4.	Industrial Economics and Foreign Trade	1	3
5.	English for Communication	1 Theory	2
		1 Lab	2
6.	Energy and Environmental Engineering	1	2
7.	Professional Ethics	1	3
8.	Engineering Graphics	1	3
9.	Engineering Practice	1	2
10.	Basic Engineering	2	4
11.	Introduction to computer Programming	1	3
12.	Branch Specific Course# (Introduction to the Branch of study)	1	2
13.	Summer Internship	1	2
14.	Project work	--	--
15.	Comprehensive viva	1	1
16.	Industrial Lecture	1	1
17.	NSS/NCC/NSO	1	Compulsory participation
Total		**22**	**50**

#Offered by Industrial Experts / Alumni of NITT

I. GENERAL INSTITUTE REQUIREMENTS

1. MATHEMATICS

Sl. No.	Course Code	Course Title	Credits
1	MAIR12	LINEAR ALGEBRA AND CALCULUS	**3**
2	MAIR22	COMPLEX ANALYSIS AND DIFFERENTIAL EQUATIONS	**3**
3	MAIR33	REAL ANALYSIS AND PROBABILITY THEORY	**4**
		Total	**10**

2. PHYSICS

Sl. No.	Course Code	Course Title	Credits
1	PHIR11	PHYSICS	**3**
2	PHIR12	PHYSICS LAB	**2**
		Total	**5**

3. CHEMISTRY

Sl. No.	Course Code	Course Title	Credits
1	CHIR11	CHEMISTRY	**3**
2	CHIR12	CHEMISTRY LAB	**2**
		Total	**5**

4. HUMANITIES

Sl. No.	Course Code	Course Title	Credits
1	HSIR13	INDUSTRIAL ECONOMICS AND FOREIGN TRADE	**3**
		Total	**3**

5. COMMUNICATION

Sl. No.	Course Code	Course Title	Credits
1	HSIR11	ENGLISH FOR COMMUNICATION	**4**
		Total	**4**

6. ENERGY AND ENVIRONMENTAL ENGINEERING

Sl. No.	Course Code	Course Title	Credits
1	ENIR11	ENERGY AND ENVIRONMENTAL ENGINEERING	**2**
		Total	**2**

7. PROFESSIONAL ETHICS

Sl. No.	Course Code	Course Title	Credits
1	HSIR14	PROFESSIONAL ETHICS	**3**
		Total	**3**

8. ENGINEERING GRAPHICS

Sl. No.	Course Code	Course Title	Credits
1	MEIR12	ENGINEERING GRAPHICS	**3**
		Total	**3**

9. ENGINEERING PRACTICE

Sl. No.	Course Code	Course Title	Credits
1	PRIR11	ENGINEERING PRACTICE	**2**
		Total	**2**

10. BASIC ENGINEERING

Sl. No.	Course Code	Course Title	Credits
1	CEIR11	BASICS OF CIVIL ENGINEERING	**2**
2	MEIR11	BASICS OF MECHANICAL ENGINEERING	**2**
		Total	**4**

11. INTRODUCTION TO COMPUTER PROGRAMMING

Sl. No.	Course Code	Course Title	Credits
1	CSIR11	INTRODUCTION TO COMPUTER PROGRAMMING	**3**
		Total	**3**

12. BRANCH SPECIFIC COURSE

Sl. No.	Course Code	Course Title	Credits
1	ECIR15	Introduction to Electronics and communication Engineering	**2**
		Total	**2**

13. SUMMER INTERNSHIP

Sl. No.	Course Code	Course Title	Credits
1	ECIR16	INTERNSHIP / INDUSTRIAL TRAINING / ACADEMIC ATTACHMENT (2 to 3 months duration during summer vacation)	**2**
		Total	**2**

The student should undergo industrial training/internship for a minimum period oftwo months during the summer vacation of 3rdyear. Attachment with an academic institution within the country (IISc/IITs/NITs/IIITsand CFTIs) or university abroad is also permitted instead of industrial training.

 # To be evaluated at the beginning of VII semester by assessing the report and seminar presentations.

14. PROJECT WORK

Sl. No.	Course Code	Course Title	Credits
1	ECIR17$	Project work/equivalent number of electives	**6**
		Total	**6**
$ Optional			

15. COMPREHENSIVE VIVA

Sl. No.	Course Code	Course Title	Credits
1	ECIR18	COMPREHENSIVE VIVA	**1**
		Total	**1**

16. INDUSTRIAL LECTURE

Sl. No.	Course Code	Course Title	Credits
1	ECIR19	INDUSTRIAL LECTURE	**1**
		Total	**1**

A course based on industrial lectures shall be offered for 1 credit. A minimum of five lectures of two hours duration by industry experts will be arranged by the Department. The evaluation methodology, will in general, be based on quizzes at the end of each lecture.

17. NSS / NCC / NSO

Sl. No.	Course Code	Course Title	Credits
1	SWIR11	NSS / NCC / NSO	**0**
		Total	**0**

II. PROGRAMME CORE (PC)

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1.	ECPC10	SIGNALS AND SYSTEMS	NONE	4
2.	ECPC11	NETWORK ANALYSIS AND SYNTHESIS	NONE	4
3.	ECPC12	ELECTRODYNAMICS AND ELECTROMAGNETIC WAVES	NONE	4
4.	ECPC13	SEMICONDUCTOR PHYSICS AND DEVICES	NONE	4
5.	ECPC14	DIGITAL CIRCUITS AND SYSTEMS	NONE	3
6.	ECPC15	DIGITAL SIGNAL PROCESSING	ECPC10	4
7.	ECPC16	TRANSMISSION LINES AND WAVEGUIDES	ECPC12	3
8.	ECPC17	ELECTRONIC CIRCUITS	ECPC13	3
9.	ECPC18	ANALOG COMMUNICATION	ECPC10	3
10.	ECPC19	DIGITAL COMMUNICATION	ECPC10	3
11.	ECPC20	ANTENNAS AND PROPAGATION	ECPC12	3
12.	ECPC21	ANALOG INTEGRATED CIRCUITS	ECPC17	3

13.	ECPC22	WIRELESS COMMUNICAITON	ECPC19	3
14.	ECPC23	VLSI SYSTEMS	ECPC21	3
15.	ECPC24	RF AND MICROWAVE ENGINEERING	ECPC16	3
			Total	**50**

III. ELECTIVES

a. PROGRAMME ELECTIVE (PE)

Students who are pursuing B.Tech. in Electronics and Communication Engineering should complete at least three courses from the Programme Electives listed below.

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1.	ECPE10	NETWORKS AND PROTOCOLS	NONE	3
2.	ECPE11	WIRELESS LOCAL AREA NETWORK	ECPE10	3
3.	ECPE12	MICROPROCESSORS AND MICROCONTROLLERS	NONE	3
4.	ECPE13	COMPUTER ARCHITECTURE AND ORGANIZATION	NONE	3
5.	ECPE14	EMBEDDED SYSTEMS	NONE	3
6.	ECPE15	OPERATING SYSTEMS	NONE	3
7.	ECPE16	ARM SYSTEM ARCHITECTURE	NONE	3
8.	ECPE17	STATISTICAL THEORY OF COMMUNICATION	NONE	3
9.	ECPE18	DIGITAL SIGNAL PROCESSORS AND APPLICATIONS	ECPC15	3
10.	ECPE19	HIGH SPEED SYSTEM DESIGN	NONE	3
11.	ECPE20	DIGITAL SPEECH PROCESSING	ECPC15	3
12.	ECPE21	DIGITAL IMAGE PROCESSING	NONE	3
13.	ECPE22	PATTERN RECOGNITION	NONE	3
14.	ECPE23	DISPLAY SYSTEMS	ECPC13	3
15.	ECPE24	INTERNET OF THINGS	CSIR11, ECPE12, C/C++ and Python Programming skills	3
16.	ECPE26	COGNITIVE RADIO	ECPC15	3
17.	ECPE27	MULTIMEDIA COMMUNICATION TECHNOLOGY	ECPC15	3
18.	ECPE28	COMMUNICATION SWITCHING SYSTEMS	ECPC18	3
19.	ECPE29	BROADBAND ACCESS TECHNOLOGIES	ECPC18 & ECPC19	3
20.	ECPE30	MICROWAVE COMPONENTS AND CIRCUITS	ECPC16	3
21.	ECPE31	FIBER OPTIC COMMUNICATION	ECPC12 & ECPC18	3
22.	ECPE32	DIGITAL SIGNAL PROCESSING FOR WIRELESS COMMUNICATION	ECPC15	3

23.	ECPE33	MICROWAVE INTEGRATED CIRCUIT DESIGN	ECPC16 & ECPC24	3
24.	ECPE34	RF MEMS CIRCUIT DESIGN	ECPC16 & ECPC24	3
25.	ECPE35	SATELLITE COMMUNICATION	ECPC18	3
26.	ECPE36	PRINCIPLES OF RADAR	ECPC20	3
27.	ECPE37	LOW POWER VLSI CIRCUITS	ECPC23	3
28.	ECPE38	ADHOC WIRELESS NETWORKS	ECPE10	3
29.	ECPE39	WIRELESS SENSOR NETWORKS	ECPE10	3
30.	ECPE40	NANO ELECTRONICS	NONE	3
31.	ECPE41	ELECTRONIC DESIGN AUTOMATION TOOLS	NONE	3
32.	ECPE42	ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY	NONE	3
33.	ECPE43	COMPUTER VISION	NONE	3
34.	ECPE44	NATURAL LANGUAGE PROCESSING	NONE	3
35.	ECPE45	OPTIMIZATION METHODS IN MACHINE LEARNING	NONE	3
36.	ECPE46	HARDWARE FOR DEEP LEARNING	NONE	3
37.	ECPE47	IMAGE AND VIDEO PROCESSING	NONE	3
38.	ECPE48	AUTOMATED TEST ENGINEERING FOR ELECTRONICS	NONE	3
39.	ECPE49	FOUNDATIONS OF ARTIFICIAL INTELLIGENCE	NONE	3
40.	ECPE50	PHOTONICS AND INTEGRATED CIRCUITS	NONE	3
41.	ECPE51	MICROWAVE CIRCUITS	NONE	3
42.	ECPE52	INTRODUCTION TO MACHINE LEARNING	NONE	3
43.	ECPE53	DEEP LEARNING	NONE	
			Total	**129**

b. OPEN ELECTIVE (OE)

The courses listed below are offered by the Department of Electronics and Communication Engineering for students of other Departments.

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1.	ECOE10	MICROWAVE INTEGRATED CIRCUITS	NONE	3
2.	ECOE11	RF MEMS CIRCUIT	NONE	3
3.	ECOE12	HIGH SPEED SYSTEM DESIGN	NONE	3
4.	ECOE13	DIGITAL SPEECH PROCESSING	ECPC15	3
5.	ECOE14	DIGITAL IMAGE PROCESSING	NONE	3
6.	ECOE15	PATTERN RECOGNITION	NONE	3
7.	ECOE16	COMPUTER ARCHITECTURE AND ORGANIZATION	NONE	3
8.	ECOE17	OPERATING SYSTEMS	NONE	3
9.	ECOE18	WIRELESS SENSOR NETWORKS	ECPE10	3
10.	ECOE19	ARM SYSTEM ARCHITECTURE	NONE	3
11.	ECOE20	LOW POWER VLSI CIRCUITS	ECPC23	3
12.	ECOE21	COMPUTER VISION AND MACHINE LEARNING	NONE	3

13.	ECOE22	TEXT DATA MINING	NONE	3
14.	ECOE23	INTERNET OF THINGS	CSIR11, C/C++, Python Programming skills	3
15.	ECOE51	NPTEL - Semiconductor Optical Communication Components and Devices	NONE	3
16.	ECOE52	NPTEL - Fundamentals of MIMO Wireless Communication	ECPC22	3
17.	ECOE53	NPTEL - Modern Digital Communication Techniques	ECPC19	3
18.	ECOE54	NPTEL - VLSI Design Verification and Test	ECPC23	3
19.	ECOE55	NPTEL - Digital VLSI Testing	ECPC23	3
20.	ECOE56	NPTEL - Analog Circuits and Systems through SPICE Simulation	ECPC17	3
21.	ECOE57	NPTEL - Linux Programming and Scripting	NONE	3
22.	ECOE58	NPTEL - Digital System Design with PLDs and FPGAs	ECPC14	3
23.	ECOE59	NPTEL - MEMS and Microsystems	NONE	3
24.	ECOE60	NPTEL - Neural Networks and Applications	NONE	3
25.	ECOE61	NPTEL - Biomedical Signal Processing	NONE	3
26.	ECOE62	NPTEL - Evolution of Air Interface Towards 5G	NONE	3
27.	ECOE63	NPTEL - Introduction to Machine Learning	NONE	3
28.	ECOE64	NPTEL - A Brief Introduction of Micro – Sensors	NONE	3
29.	ECOE65	NPTEL - An Introduction to Coding Theory	NONE	3
30.	ECOE66	NPTEL - Deep Learning	NONE	3
31.	ECOE67	NPTEL - Python for everybody	NONE	3
32.	ECOE68	NPTEL - Cryptography and network security	NONE	3
33.	ECOE69	NPTEL - Blockchain architecture design and use cases	NONE	3
34.	ECOE70	NPTEL - Optical sensors	NONE	3
35.	ECOE71	NPTEL - Non -linear adaptive control	NONE	3
36.	ECOE72	NPTEL - Modelling & simulation of dynamic systems	NONE	3
37.	ECOE73	NPTEL - Bio informatics: algorithm & applications	NONE	3
38.	ECOE74	NPTEL - ANALOG IC DESIGN	NONE	3
39.	ECOE75	NPTEL - PETROLEUM ECONOMICS AND MANAGEMENT	NONE	3
40.	ECOE76	COMPUTER VISION	NONE	3
41.	ECOE77	NATURAL LANGUAGE PROCESSING	NONE	3
42.	ECOE78	OPTIMIZATION METHODS IN MACHINE LEARNING	NONE	3
43.	ECOE79	HARDWARE FOR DEEP LEARNING	NONE	3
44.	ECOE80	IMAGE AND VIDEO PROCESSING	NONE	3

45.	ECOE81	AUTOMATED TEST ENGINEERING FOR ELECTRONICS	NONE	3
46.	ECOE82	FOUNDATIONS OF ARTIFICIAL INTELLIGENCE	NONE	3
47.	ECOE83	PHOTONICS AND INTEGRATED CIRCUITS	NONE	3
48.	ECOE84	MICROWAVE CIRCUITS	NONE	3
			Total	144

c. MINOR (MI)

Students who have registered for B.Tech Minor in ELECTRONICS AND COMMUNICATION ENGINEERING can opt to study any 5 of the courses listed below.

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1.	ECMI10	SIGNALS AND SYSTEMS	NONE	3
2.	ECMI11	NETWORK ANALYSIS AND SYNTHESIS	NONE	3
3.	ECMI12	ELECTRODYNAMICS AND ELECTROMAGNETIC WAVES	NONE	3
4.	ECMI13	SEMICONDUCTOR PHYSICS AND DEVICES	NONE	3
5.	ECMI14	DIGITAL CIRCUITS AND SYSTEMS	NONE	3
6.	ECMI15	DIGITAL SIGNAL PROCESSING	ECMI10	3
7.	ECMI16	TRANSMISSION LINES AND WAVEGUIDES	ECMI12	3
8.	ECMI17	ELECTRONIC CIRCUITS	ECMI13	3
9.	ECMI18	MICROPROCESSORS AND MICRO CONTROLLERS	ECMI14	3
10.	ECMI19	DIGITAL SIGNAL PROCESSORS AND APPLICATIONS	ECMI15	3
11.	ECMI20	ANALOG COMMUNICATION	ECMI10	3
12.	ECMI21	ANTENNAS AND PROPAGATION	ECMI12	3
13.	ECMI22	ANALOG INTEGRATED CIRCUITS	ECMI17	3
14.	ECMI23	DIGITAL COMMUNICATION	ECMI20	3
15.	ECMI24	MICROWAVE COMPONENTS AND CIRCUITS	ECMI16	3
16.	ECMI25	VLSI SYSTEMS	ECMI14	3
17.	ECMI26	WIRELESS COMMUNICAITON	ECMI23	3
18.	ECMI27	FIBER OPTIC COMMUNICATION	ECMI12 &ECMI20	3
19.	ECMI28	MICROWAVE ELECTRONICS	ECMI24	3
			Total	**57**

Note: Student should be allowed a minimum of 50% of the total electives of a programme from Open electives and Minor, if so desired by the student.

(IV) ESSENTIAL PROGRAMME LABORATORY REQUIREMENT (ELR)

Sl. No.	Course Code	Course Title	Co-requisites	Credits
1.	ECLR10	DEVICES AND NETWORKS LABORATORY	ECPC13	2
2.	ECLR11	DIGITAL ELECTRONICS LABORATORY	ECPC14	2
3.	ECLR12	ELECTRONIC CIRCUITS LABORATORY	ECPC17	2
4.	ECLR13	MICROPROCESSOR AND MICROCONTROLLER LABORATORY		2
5.	ECLR14	ANALOG VLSI & EMBEDDED SYSTEM DESIGN LABORATORY	ECPC21 &ECPC23	2
6.	ECLR15	DIGITAL SIGNAL PROCESSING LABORATORY	ECPC15	2
7.	ECLR16	COMMUNICATION ENGINEERING LABORATORY	ECPC18 &ECPC19	2
8.	ECLR17	MICROWAVE & FIBER OPTIC LABORATORY	ECPC24	2
			Total	**16**

NOTE: Students can register for 2 laboratory courses during one session along with regular courses (PC / PE / OE / MI).

V. ADVANCED LEVEL COURSES FOR B.Tech. (HONOURS)

A student can obtain B.Tech. (Honours) degree provided the student has;

i. Registered at least for 12 theory courses and 2 ELRs in the second year.
ii. Consistently obtained a minimum GPA of 8.5 in the first four sessions
iii. Continue to maintain the same GPA of 8.5 in the subsequent sessions (including the Honours courses)
iv. Completed 3 additional theory courses specified for the Honors degree of the programme.
v. Completed all the courses registered, in the first attempt and in four years of study.

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1.	ECHO11	SPECTRAL ANALYSIS OF SIGNALS	ECPC15	3
2.	ECHO12	DETECTION AND ESTIMATION	MAIR 32	3
3.	ECHO13	WAVELET SIGNAL PROCESSING	ECPC15	4
4.	ECHO14	RF CIRCUITS	NONE	3
5.	ECHO15	NUMERICAL TECHNIQUES FOR MIC	ECPE30	3
6.	ECHO16	APPLIED PHOTONICS	NONE	3
7.	ECHO17	ADVANCED RADIATION SYSTEMS	ECPE17	3
8.	ECHO18	BIO MEMS	NONE	3
9.	ECHO19	ANALOG IC DESIGN	ECPE18	3
10.	ECHO20	VLSI SYSTEM TESTING	ECPC23	3
11.	ECHO22	DESIGN OF ASICS	NONE	4
12.	ECHO23	DIGITAL SYSTEM DESIGN	ECPC14	3

13.	ECHO24	OPTIMIZATIONS OF DIGITAL SIGNAL PROCESSING STRUCTURES FOR VLSI	ECPC23 &ECPE18	4
14.	ECHO25	LOW POWER VLSI CIRCUITS	ECPC23	3
15.	ECHO26	VLSI DIGITAL SIGNAL PROCESSING SYSTEMS	ECPC15 &ECPC23	3
16.	ECHO27	ASYNCHRONOUS SYSTEM DESIGN	ECPC14	3
17.	ECHO28	PHYSICAL DESIGN AUTOMATION	NONE	3
18.	ECHO29	MIXED - SIGNAL CIRCUIT DESIGN	NONE	3
19.	ECHO30	DIGITAL SIGNAL PROCESSING FOR MEDICAL IMAGING	ECPC15	4
20.	ECHO31	Advanced Techniques for Wireless Reception	-	3
21.	ECHO32	Error Control Coding	-	3
22.	ECHO33	Digital Communication Receivers	-	3
23.	ECHO34	ADVANCED DIGITAL SIGNAL PROCESSING	ECPC15	4
24.	ECHO35	PHOTONICS AND INTEGRATED CIRCUITS	-	3
25.	ECHO36	MICROWAVE CIRCUITS	-	3
			Total	**80**

This syllabus is also applicable for students admitted in 2019-2020 onwards.

Course Code	**:**	**MAIR32**
Course Title	**:**	**REAL ANALYSIS AND PROBABILITY THEORY**
Number of Credits		**4**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**GIR**

Course Learning Objective

- To expose the students to the basics of real analysis and probability theory required for their subsequent course work.

Course Content

Real Analysis: Real number system. Sets, relations and functions. Properties of real numbers. sequences. Cauchy sequences. Bolzano-Weierstrass and Heine-Borel properties.

Reimann integral. Mean value theorems. Sequences and series of functions. Pointwise and uniform convergence. Power series and Taylor series.

Probability Theory: Random Variable and random vectors - Distributions and densities. – Functions of one and two random variables. Moments and characteristic functions.

Random processes - Strict sense and wide sense stationary processes - Covariance functions and their properties - Spectral representation - Wiener-Khinchine theorem.

Gaussian processes – Poisson processes - Lowpass and Bandpass noise representations. .

Text Books

1. *W.Rudin, "Introduction to Principles of Mathematical Analysis", McGraw-Hill International Editions, Third Edition, 1976.*
2. *Davenport," Probability and Random Processes for Scientist and Engineers", McGraw-Hill, 1970.*
3. *Papoulis. A.," Probability, Random variables and Stochastic Processes", McGraw Hill, 2002.*

Reference Books

1. *Kreyszig.E. "Advanced Engineering Mathematics", John Wiley, 1999.*
2. *S.C. Malik, Savita Arora, "Mathematical Analysis", New Age International Ltd, 4th Edition, 2012.*
3. *G.B.Gustafson & C.H. Wilcox, "Advanced Engineering Mathematics", Springer Verlag, 1998.*

Course outcomes

At the end of the course student will be able

CO1: Develops an understanding for the construction of proofs and an appreciation for deductive logic.

CO2: Explore the already familiar properties of the derivative and the Riemann Integral, set on a more rigorous and formal footing which is central to avoiding inconsistencies in engineering applications.

CO3: Explore new theoretical dimensions of uniform convergence, completeness and important consequences as interchange of limit operations.

CO4: understand the concept of random processes and determine covariance and spectral density of stationary random processes.

CO5: demonstrate the specific applications to Poisson and Gaussian processes and representation of low pass and band pass noise models.

Course Code	**:**	**ECPC10**
Course Title	**:**	**SIGNALS AND SYSTEMS**
Number of Credits		**4**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**PC**

Course Learning Objectives

- To make the students to understand the fundamental characteristics of signals and systems in terms of both the time and transform domains
- Development of the mathematical skills to solve problems involving convolution, filtering, modulation and sampling.

Course Content

Definition of Signals and Systems, Classification of Signals, Operations on signals, Singularity functions and related functions. Analogy between vectors and signals - orthogonal signal space, complete set of orthogonal functions, Parseval's relations. Fourier series representation of continuous time periodic signals -Trigonometric and Exponential Fourier series- Properties of Fourier series.

Fourier transform of aperiodic signals, standard signals and periodic signals - Properties of Fourier transforms. Hilbert transform and its properties. Laplace transforms-RoC-properties. Inverse Laplace transform.

Continuous-time Systems and its properties. Linear time invariant (LTI) system-Impulse response. Convolution. Analysis of LTI System using Laplace and Fourier transforms.

Sampling and reconstruction of band limited signals. Low pass and band pass sampling theorems. Aliasing. Anti-aliasing filter. Practical Sampling-aperture effect.

Discrete-time signals and systems. Discrete Fourier series. Z-transform and its properties. Analysis of LSI systems using Z – transform.

Text Books

1. *A.V.Oppenheim, A. Willsky, S. Hamid Nawab, "Signals and Systems (2/e)", Pearson 200.*
2. *S.Haykin and B.VanVeen "Signals and Systems, Wiley, 1998.*

Reference Books

1. *M.Mandal and A.Asif, "Continuous and Discrete Time Signals and Systems, Cambridge, 2007.*
2. *D.C.Lay, "Linear Algebra and its Applications (2/e)", Pearson, 200.*
3. *S.S.Soliman & M.D.Srinath, "Continuous and Discrete Signals and Systems", Prentice- Hall, 1990.*

Course outcomes

At the end of the course student will be able to

CO1: Understand the mathematical description and representation of continuous-time and discrete-time signals.

CO2: Analyze the spectral characteristics of continuous-time periodic and aperiodic signals using Fourier analysis.

CO3: Analyse system properties based on impulse response and Fourier analysis

CO4: Convert a continuous time signal into discrete time signal and reconstruct the continuous time signals back from its samples

CO5: Apply the Laplace transform and Z- transform respectively for the analyse of continuous-time and discrete-time signals.

Course Code	**:**	**ECPC11**
Course Title	**:**	**NETWORK ANALYSIS AND SYNTHESIS**
Number of Credits		**4**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**PC**

Course Learning Objectives

- To make the students capable of analysing any given electrical network.
- To make the students to learn synthesis of an electrical network for a given impedance/ admittance function.

Course Content

Network concept. Elements and sources. Kirchhoff's laws. Tellegen's theorem. Network equilibrium equations. Node and Mesh method. Source superposition. Thevenin's and Norton's theorems. Network graphs.

First and second order networks. State equations. Transient response. Network functions. Determination of the natural frequencies and mode vectors from network functions.

Sinusoidal steady-state analysis. Maximum power-transfer theorem. Resonance. Equivalent and dual networks. Design of equalizers.

Two-port network parameters. Interconnection of two port networks. Barlett's bisection theorem. Image and Iterative parameters. Design of attenuators.

Two-terminal network synthesis. Properties of Hurwitz polynomial and Positive real function. Synthesis of LC, RC and RL Networks, Foster Forms and Cauer Forms.

Text Books

1. *Hayt W. H., Kemmerly J. E. and Durbin S. M., "Engineering Circuit Analysis", 6th Ed., TataMcGraw-Hill Publishing Company Ltd., 2008.*
2. *F.F. Kuo, "Network analysis and Synthesis", Wiley International Edition, 2008.*

Reference Books

1. *Valkenberg V., "Network Analysis", 3rd Ed., Prentice Hall International Edition, 2007.*
2. *B.S.Nair and S.R.Deepa, "Network analysis and Synthesis", Elsevier, 2012.*

Course outcomes

At the end of the course student will be able

CO1: analyse the electric circuit using network theorems

CO2: understand and Obtain Transient & Forced response

CO3: determine Sinusoidal steady state response; understand the real time applications of maximum power transfer theorem and equalizer

CO4: understand the two–port network parameters, are able to find out two-port network parameters & overall response for interconnection of two-port networks.

CO5: synthesize one port network using Foster form, Cauer form.

Course Code	**:**	**ECPC12**
Course Title	**:**	**ELECTRODYNAMICS AND ELECTROMAGNETIC WAVES**
Number of Credits		**4**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**PC**

Course Learning Objective

- To expose the students to the rudiments of Electromagnetic theory and wave propagation essential for subsequent courses on microwave engineering, antennas and wireless communication

Course Content

Electrostatics. Coulomb's law. Gauss's law and applications. Electric potential. Poisson's and Laplace equations. Method of images. Multipole Expansion.

Electrostatic fields in matter. Dielectrics and electric polarization. Capacitors with dielectric substrates. Linear dielectrics. Force and energy in dielectric systems.

Magneto-statics. Magnetic fields of steady currents. Biot-Savart's and Ampere's laws. Magnetic vector potential. Magnetic properties of matter.

Electrodynamics. Flux rule for motional emf. Faraday's law. Self and mutual inductances. Maxwell's Equations. Electromagnetic Boundary conditions. Poynting theorem.

Electromagnetic wave propagation. Uniform plane waves. Wave polarization. Waves in matter. Reflection and transmission at boundaries. Propagation in an ionized medium.

Text Books

1. *D.J.Griffiths, "Introduction to Electrodynamics (3/e)", PHI, 2001*
2. *E.C. Jordan & G. Balmain, "Electromagnetic Waves and Radiating Systems", PHI, 1995.*

Reference Books

1. *W.H.Hayt, "Engineering Electromagnetics, (7/e)", McGraw Hill, 2006.*
2. *D.K.Cheng, "Field and Wave Electromagnetics, (2/e)", Addison Wesley, 1999.*
3. *M.N.O.Sadiku, "Principles of Electromagnetics, (4/e)", Oxford University Press, 2011.*
4. *N.NarayanaRao, "Elements of Engineering Electromagnetics, (6/e)", Pearson, 2006.*
5. *R.E.Collin, "Foundations for Microwave Engineering (2/e)", McGraw –Hill, 2002.*
6. *R.E.Collin, "Antennas and Radio wave Propagation", McGraw-Hill, 1985.*

Course outcomes

At the end of the course student will be able

CO1: recognize and classify the basic Electrostatic theorems and laws and to derive them.
CO2: discuss the behaviour of Electric fields in matter and Polarization concepts.
CO3: classify the basic Magneto static theorems and laws and infer the magnetic properties of matter.
CO4: summarize the concepts of electrodynamics &to derive and discuss the Maxwell's equations.
CO5: students are expected to be familiar with Electromagnetic wave propagation and wave polarization.

Course Code	**:**	**ECPC13**
Course Title	**:**	**SEMICONDUCTOR PHYSICS AND DEVICES**
Number of Credits		**4**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**PC**

Course Learning Objectives

- To make the students understand the fundamentals of electronic devices.
- To train them to apply these devices in mostly used and important applications.

Course Content

Semiconductor materials: crystal growth, film formation, lithography, etching and doping. Formation of energy bands in solids, Concept of hole, Intrinsic and extrinsic semiconductors, conductivity, Equilibrium Carrier concentration, Density of states and Fermi level, Carrier transport – Drift and Diffusion, continuity equation, Hall effect and its applications.

P-N junction diodes, Energy band diagram, biasing, V-I characteristics, capacitances. Diode models, Break down Mechanisms, Rectifiers, Limiting and Clamping Circuits, types of diodes.

BJT Physics and Characteristics modes of operation, Ebers-Moll Model, BJT as a switch and Amplifier, breakdown mechanisms, Photo devices.

MOSFET: Ideal I-V characteristics, non-ideal I-V effects, MOS Capacitor, MOSFET as switch, CMOS Logic gate Circuits, Bi-CMOS circuits, CCDs.

State-of-the-art MOS technology: small-geometry effects, FinFETs, Ultrathin body FETs. Display devices, Operation of LCDs, Plasma, LED and HDTV

Text Books

1. *S.M.Sze, Semiconductors Devices, Physics and Technology, (2/e), Wiley, 2002*
2. *A.S.Sedra & K.C.Smith, Microelectronic Circuits (5/e), Oxford, 2004*

Reference Books

1. *L.Macdonald & A.C.Lowe, Display Systems, Wiley, 2003*
2. *Robert Pierret, "Semiconductor Device Fundamentals," Pearson Education, 2006*
3. *J.Millman and C.C.Halkias: Electronic devices and Circuits, McGraw Hill, 1976.*
4. *B.G.Streetman: Solid state devices, (4/e), PHI, 1995.*
5. *N.H.E.Weste, D. Harris, "CMOS VLSI Design (3/e)", Pearson, 2005.*

Course outcomes

At the end of the course student will be able

CO1: Apply the knowledge of basic semiconductor material physics and understand fabrication processes.

CO2: Analyze the characteristics of various electronic devices like diode, transistor etc.,

CO3: Classify and analyze the various circuit configurations of Transistor and MOSFETs.

CO4: Illustrate the qualitative knowledge of Power electronic Devices.

CO5: Become Aware of the latest technological changes in Display Devices.

Course Code	**:**	**ECPC14**
Course Title	**:**	**DIGITAL CIRCUITS AND SYSTEMS**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**PC**

Course Learning Objective

- To introduce the theoretical and circuit aspects of digital electronics, which is the back bone for the basics of the hardware aspect of digital systems

Course Content

Review of number systems-representation-conversions, error detection and error correction. Review of Boolean algebra- theorems, sum of product and product of sum simplification, canonical forms-min term and max term, Simplification of Boolean expressions-Karnaugh map, completely and incompletely specified functions, Implementation of Boolean expressions using universal gates.

Combinational logic circuits- adders, subtractors, BCD adder, ripple carry look ahead adders, parity generator, decoders, encoders, multiplexers, de-multiplexers, Realization of Boolean expressions-using decoders-using multiplexers. Memories – ROM- organization, expansion. PROMs. Types of RAMs – Basic structure, organization, Static and dynamic RAMs, PLDs, PLAs.

Sequential circuits – latches, flip flops, edge triggering, asynchronous inputs. Shift registers, Universal shift register, applications. Binary counters – Synchronous and asynchronous up/down counters, mod-N counter, Counters for random sequence.

Synchronous circuit analysis and design: structure and operation, analysis-transition equations, state tables and state diagrams, Modelling- Moore machine and Mealy machine- serial binary adder, sequence recogniser, state table reduction, state assignment. Hazard; Overview and comparison of logic families.

Introduction to Verilog HDL, Structural, Dataflow and behavioural modelling of combinational and sequential logic circuits.

Text Books

1. *Wakerly J F, "Digital Design: Principles and Practices, Prentice-Hall", 2nd Ed., 2002.*
2. *D. D. Givone, "Digital Principles and Design", Tata Mc-Graw Hill, New Delhi, 2003.*

Reference Books

1. *S.Brown and Z.Vranesic, "Fundamentals of Digital Logic with Verilog Design", Tata Mc-Graw Hill, 2008.*
2. *D.P. Leach, A. P. Malvino, Goutam Guha, "Digital Principles and Applications", Tata Mc-Graw Hill, New Delhi, 2011.*
3. *M. M. Mano, "Digital Design", 3rd ed., Pearson Education, Delhi, 2003.*
4. *R.J.Tocci and N.S.Widner, "Digital Systems - Principles& Applications", PHI, 10th Ed., 2007.*
5. *Roth C.H., "Fundamentals of Logic Design", Jaico Publishers. V Ed., 2009.*
6. *T. L. Floyd and Jain,"Digital Fundamentals", 8th ed., Pearson Education, 2003.*

Course outcomes

At the end of the course student will be able to

CO1: Apply the knowledge of Boolean algebra and simplification of Boolean expressions to deduce optimal digital circuits.

CO2: Study and examine the SSI, MSI and Programmable combinational circuits.

CO3: Study and investigate the sequential networks suing counters and shift registers; summarize the performance of logic families with respect to their speed, power consumption, number of ICs and cost.

CO4: Work out SSI and MSI digital networks given a state diagram based on Mealy and Moore configurations. Summarize the performance of logic families with respect to their speed, power consumption, number of ICs and cost.

CO5: Code combinational and sequential circuits using Virology HDL.

Course Code	**:**	**ECPC15**
Course Title	**:**	**DIGITAL SIGNAL PROCESSING**
Number of Credits		**4**
Prerequisites (Course code)	**:**	**ECPC10**
Course Type	**:**	**PC**

Course Learning Objective

(i) To study about discrete-time Fourier transform (DTFT), the concepts of frequency response characteristics of a discrete-time systems, DFT and its fast computation.
(ii) To make the students able to design digital filters (FIR and IIR) and implement in various forms.
(iii) To study and understand the concept of multirate DSP systems and its applications

Course Content

Review of LSI system, DTFT, Frequency response of discrete time systems, all pass inverse, linear phase and minimum phase systems.

DFT, Relationship of DFT to other transforms, FFT, DIT and DIF, FFT algorithm, Linear filtering using DFT and FFT.

Characteristics of FIR Digital Filters, types and frequency response - Design of FIR digital filters using window techniques and frequency sampling technique - basic structures and lattice structure for FIR systems.

Analog filter approximations – Butter worth and Chebyshev, Design of IIR Digital filters from analog filters, Analog and Digital frequency transformations - Basic structures of IIR systems, Transposed forms.

Sampling rate conversion by an integer and rational factor, Poly phase FIR structures for sampling rate conversion.

Text Books

1. *J.G.Proakis, D.G. Manolakis, "Digital Signal Processing", (4/e) Pearson, 2007.*
2. *A.V.Oppenheim & R.W.Schafer, "Discrete Time Signal processing", (2/e), Pearson Education, 2003.*

Reference Books

1. *S.K.Mitra, "Digital Signal Processing (3/e)", Tata McGraw Hill, 2006.*
2. *P.S.R.Diniz, E.A.B.da Silva and S.L.Netto, "Digital Signal Processing", Cambridge, 2002.*
3. *E.C.Ifeachor & B.W.Jervis, "Digital Signal Processing", (2/e), Pearson Education, 2002.*
4. *J.R.Jhonson, "Introduction to Digital Signal Processing", Prentice-Hall, 1989.*

Course outcomes

At the end of the course student will be able to

CO1: analyze discrete-time systems in both time & transform domain and also through pole-zero placement.
CO2: analyze discrete-time signals and systems using DFT and FFT.
CO3: design and implement digital finite impulse response (FIR) filters.
CO4: design and implement digital infinite impulse response (IIR) filters.
CO5: understand and develop multirate digital signal processing systems.

Course Code	**:**	**ECPC16**
Course Title	**:**	**TRANSMISSION LINES AND WAVEGUIDES**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECPC12**
Course Type	**:**	**PC**

Course Learning Objective

- To expose students to the complete fundamentals and essential feature of waveguides, resonators and microwave components and also able to give an introduction to microwave integrated circuit design.

Course Content

Classification of guided wave solutions-TE, TM and TEM waves. Field analysis transmission lines.

Rectangular and circular waveguides. Excitation of waveguides. Rectangular and circular cavity resonators.

Transmission line equations. Voltage and current waves. Solutions for different terminations. Transmission-line loading.

Impedance transformation and matching. Smith Chart, Quarter-wave and half-wave transformers. Binomial and T chebeyshev transformers. Single, double and triple stub matching.

Micro-striplines, stripline, slot lines, coplanar waveguide and fin line. Micro strip MIC design aspects. Computer- aided analysis and synthesis.

Text Books

1. *D.M.Pozar, "Microwave Engineering (3/e)" Wiley, 2004.*
2. *J.D.Ryder, "Networks, Lines and Fields", PHI, 2003.*

Reference Books

1. *R.E.Collin, "Foundations for Microwave Engineering (2/e)", McGraw-Hill, 2002.*
2. *S.Y.Liao, "Microwave Devices and Circuits", (3/e) PHI, 2005.*
3. *J. A. Seeger, "Microwave Theory, Components, and Devices" Prentice-Hall-A division of Simon & Schuster Inc Englewood Cliffs, New Jersy 07632, 1986.*

Course outcomes

At the end of the course student will be able

CO1: classify the Guided Wave solutions -TE, TM, and TEM.

CO2: analyze and design rectangular waveguides and understand the propagation of electromagnetic waves.

CO3: evaluate the resonance frequency of cavity Resonators and the associated modal field.

CO4: analyze the transmission lines and their parameters using the Smith Chart.

CO5: apply the knowledge to understand various planar transmission lines.

Course Code	**:**	**ECPC17**
Course Title	**:**	**ELECTRONIC CIRCUITS**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECPC13**
Course Type	**:**	**PC**

Course Learning Objective

- To make the students understand the fundamentals of electronic circuits.

Course Content

Load line, operating point, biasing methods for BJT and MOSFET. Low frequency and high models of BJT and MOSFET, Small signal Analysis of CE, CS, CD and Cascade amplifier

MOSFET amplifiers: Current mirrors: Basic current mirror, Cascade current mirror, Single-ended amplifiers: CS amplifier – with resistive load, diode connected load, current source load, triode load, source degeneration. CG and CD amplifiers, Cascade amplifier,

Frequency response of amplifiers, Differential Amplifiers, CMRR, Differential amplifiers with active load, two stage amplifiers

Feedback concept, Properties, Feedback amplifiers, Stability analysis, Condition for oscillation, Sinusoidal oscillators.

Power amplifiers- class A, class B, class AB, Biasing circuits, class C and class D

Text Books

1. *A.S.Sedra & K.C.Smith, "Microelectronic Circuits (5/e)", Oxford, 2004.*
2. *D.L.Schilling & C.Belove, "Electronic Circuits: Discrete and Integrated", (3/e), McGraw Hill, 1989.*

Reference Books

1. *Behzad Razavi, "Design of Analog CMOS Integrated Circuits", (2/e), McGraw Hill, 2017.*
2. *J.Millman & Arvin Grabel, "Microelectronics", McGraw Hill, 2007.*
3. *K.V.Ramanan, "Functional Electronics", Tata McGraw Hill, 1984.*

Course outcomes

At the end of the course student will be able

CO1: illustrate about rectifiers, transistor and FET amplifiers and its biasing. Also compare the performances of its low frequency models.

CO 2: discuss about the frequency response of MOSFET and BJT amplifiers.

CO 3: illustrate about MOS and BJT differential amplifiers and its characteristics.

CO4: discuss about the feedback concepts and construct feedback amplifiers and oscillators. Also summarizes its performance parameters.

CO 5: explain about power amplifiers and its types and also analyze its characteristics.

Course Code	**:**	**ECPC18**
Course Title	**:**	**ANALOG COMMUNICATION**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECPC10**
Course Type	**:**	**PC**

Course Learning Objective

- To develop a fundamental understanding on Communication Systems with emphasis on analog modulation techniques and noise performance.

Course Content

Basic blocks of Communication System. Amplitude (Linear) Modulation – AM, DSB-SC, SSB-SC and VSB-SC. Methods of generation and detection. FDM. Super Heterodyne Receivers.

Angle (Non-Linear) Modulation - Frequency and Phase modulation. Transmission Bandwidth of FM signals, Methods of generation and detection. FM Stereo Multiplexing.

Noise - Internal and External Noise, Noise Calculation, Noise Figure. Noise in linear and nonlinear AM receivers, Threshold effect.

Noise in FM receivers, Threshold effect, Capture effect, FM Threshold reduction, Pre-emphasis and De-emphasis.

Pulse Modulation techniques – Sampling Process, PAM, PWM and PPM concepts, Methods of generation and detection. TDM. Noise performance.

Text Books

1. *S.Haykins, Communication Systems, Wiley, (4/e), Reprint 2009.*
2. *Kennedy, Davis, Electronic Communication Systems (4/e), McGraw Hill, Reprint 2008.*

Reference Books

1. *B.Carlson, Introduction to Communication Systems, McGraw-Hill, (4/e), 2009.*
2. *J.Smith, Modern Communication Circuits (2/e), McGraw Hill, 1997.*
3. *J.S.Beasley & G.M.Miler, Modern Electronic Communication (9/e), Prentice-Hall, 2008.*

Course outcomes

At the end of the course student will be able

CO1: Understand the basics of communication system and analog modulation techniques

CO2: Apply the basic knowledge of signals and systems and understand the concept of Frequency modulation.

CO3: Apply the basic knowledge of electronic circuits and understand the effect of Noise in communication system and noise performance of AM system

CO4: Understand the effect of noise performance of FM system.

CO5: Understand TDM and Pulse Modulation techniques.

Course Code	**:**	**ECPC19**
Course Title	**:**	**DIGITAL COMMUNICATION**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECPC10**
Course Type	**:**	**PC**

Course Learning Objectives

- To understand the key modules of digital communication systems with emphasis on digital modulation techniques.
- To get introduced to the basics of source and channel coding/decoding and Spread Spectrum Modulation.

Course Content

Base band transmission. Sampling theorem, Pulse code modulation (PCM), DM, Destination SNR in PCM systems with noise. Matched filter. Nyquist criterion for zero ISI. Optimum transmit and receive filters. Correlative Coding, M-ary PAM. Equalization- zero-forcing and basics of adaptive linear equalizers.

BASK, BFSK, and BPSK- Transmitter, Receiver, Signal space diagram, Error probabilities.

M-ary PSK, M-ary FSK, QAM, MSK and GMSK- Optimum detector, Signal constellation, error probability.

Linear block codes-Encoding and decoding. Cyclic codes – Encoder, Syndrome Calculator. Convolutional codes – encoding, Viterbi decoding. TCM.

Spread Spectrum (SS) Techniques- Direct Sequence Spread Spectrum modulation, Frequency-hop Spread Spectrum modulation - Processing gain and jamming margin.

Text Books

1. *S.Haykin, "Communication Systems", Wiley, (4/e), 2001.*
2. *J.G.Proakis, "Digital Communication", Tata McGraw – Hill, (4/e), 2001.*

Reference Books

1. *B.Sklar, "Digital Communications: Fundamentals & Applications", Pearson Education, (2/e), 2001.*
2. *A.B.Carlson, " Communication Systems", McGraw Hill, 3/e,2002*
3. *R.E.Zimer & R.L.Peterson," Introduction to Digital Communication", PHI,3/e, 2001*

Course outcomes

At the end of the course student will be able

CO1: Apply the knowledge of signals and system and explain the conventional digital communication system.
CO2: Apply the knowledge of statistical theory of communication and evaluate the performance of digital communication system in the presence of noise.
CO3: Describe and analyze the performance of advance modulation techniques.
CO4: Apply the knowledge of digital electronics and describe the error control codes like block code, cyclic code.
CO5: Describe and analyze the digital communication system with spread spectrum modulation.

Course Code	**:**	**ECPC20**
Course Title	**:**	**ANTENNAS AND PROPAGATION**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECPC12**
Course Type	**:**	**PC**

Course Learning Objective

- To impart knowledge on basics of antenna theory and to analyze and design a start of art antenna for wireless communications.

Course Content

Radiation fundamentals. Potential theory. Helmholtz integrals. Radiation from a current element. Basic antenna parameters. Radiation field of an arbitrary current distribution. Small loop antennas.

Receiving antenna. Reciprocity relations. Receiving cross section, and its relation to gain. Reception of completely polarized waves. Linear antennas. Current distribution. Radiation field of a thin dipole. Folded dipole. Feeding methods. Baluns.

Antenna arrays. Array factorization. Array parameters. Broad side and end fire arrays. Yagi-Uda arrays Log-periodic arrays.

Aperture antennas. Fields as sources of radiation. Horn antennas. Babinet's principle. Parabolic reflector antenna. Microstrip antennas.

Wave Propagation: Propagation in free space. Propagation around the earth, surface wave propagation, structure of the ionosphere, propagation of plane waves in ionized medium, Determination of critical frequency, MUF. Fading, tropospheric propagation, Super refraction.

Text Books

1. *R.E.Collin, "Antennas and Radio Wave Propagation", McGraw – Hill, 1985.*
2. *W.L.Stutzman & G.A.Thiele, "Antenna Theory and Design", Wiley.*

Reference Books

1. *K.F.Lee, "Principles of Antenna Theory", Wiley, 1984.*
2. *F.E. Terman, "Electronic Radio Engineering (4/e)", McGraw Hill.*
3. *J.R. James, P. S. Hall, and C. Wood, "Microstrip Antenna Theory and Design", IEE, 1981.*
4. *C.A.Balanis, "Modern Antenna Handbook", Wiley India Pvt. Limited, 2008.*

Course outcomes

At the end of the course student will be able

CO1: select the appropriate portion of electromagnetic theory and its application to antennas.

CO2: distinguish the receiving antennas from transmitting antennas, analyze and justify their characteristics.

CO3: assess the need for antenna arrays and mathematically analyze the types of antenna arrays.

CO4: distinguish primary from secondary antennas and analyze their characteristics by applying optics and acoustics principles.

CO5: outline the factors involved in the propagation of radio waves using practical antennas.

Course Code	**:**	**ECPC21**
Course Title	**:**	**ANALOG INTEGRATED CIRCUITS**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECPC17**
Course Type	**:**	**PC**

Course Learning Objective

- To introduce the theoretical & circuit aspects of an Op-amp.

Course Content

Operational Amplifiers, DC and AC characteristics, typical op-amp parameters: Finite gain, finite bandwidth, Offset voltages and currents, Common-mode rejection ratio, Power supply rejection ratio, Slew rate, Applications of Op-amp: Precision rectifiers. Summing amplifier, Integrators and differentiators, Log and antilog amplifiers. Instrumentation amplifiers, voltage to current converters.

Active filters: Second order filter transfer function (low pass, high pass, band pass and band reject), Butterworth, Chebyshev and Bessel filters. Switched capacitor filter. Notch filter, all pass filters, self-tuned filters

Opamp as a comparator, Schmitt trigger, Astable and monostable multivibrators, Triangular wave generator, Multivibrators using 555 timer, Data converters: A/D and D/A converters

PLL- basic block diagram and operation, four quadrant multipliers. Phase detector, VCO, Applications of PLL: Frequency synthesizers, AM detection, FM detection and FSK demodulation.

CMOS differential amplifiers**:** DC analysis and small signal analysis of differential amplifier with Restive load, current mirror load and current source load, Input common-mode range and Common-mode feedback circuits. OTAs Vs Opamps. Slew rate, CMRR, PSRR. Two stage amplifiers, Compensation in amplifiers (Dominant pole compensation).

Text Books

1. *S.Franco, Design with Operational Amplifiers and Analog Integrated Circuits (3/e) TMH, 2003.*
2. *Sedra and Smith, Microelectronics Circuits, Oxford Univ. Press, 2004*

Reference Books

1. *Coughlin, Driscoll, OP-AMPS and Linear Integrated Circuits, Prentice Hall, 2001.*

Course outcomes

At the end of the course student will be able

CO1: infer the DC and AC characteristics of operational amplifiers and its effect on output and their compensation techniques.

CO2: elucidate and design the linear and nonlinear applications of an op-amp and special application ICs.

CO3: explain and compare the working of multi vibrators using special application IC 555 and general purpose op-amp.

CO4: classify and comprehend the working principle of data converters.

CO5: illustrate the function of application specific ICs such as Voltage regulators, PLL and its application in communication.

Course Code	**:**	**ECPC22**
Course Title	**:**	**WIRELESS COMMUNICAITON**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECPC19**
Course Type	**:**	**PC**

Course Learning Objective

- To get an understanding of mobile radio communication principles, types and to study the recent trends adopted in cellular and wireless systems and standards**.**

Course Content

Introduction to Wireless Communication. Cellular concept. System design fundamentals. Coverage and Capacity improvement in Cellular system. Technical Challenges.

Mobile Radio Propagation; Reflection, Diffraction, Fading. Multipath propagation. Statistical characterization of multipath fading. Diversity Techniques.

Path loss prediction over hilly terrain. Practical link budget design using Path loss models. Design parameters at base station. Antenna location, spacing, heights and configurations.

Multiple access techniques; FDMA, TDMA and CDMA. Spread spectrum. Power control. WCDMA.CDMA network design. OFDM and MC-CDMA.

GSM.3G, 4G (LTE), NFC systems, WLAN technology. WLL. Hyper LAN. Ad hoc networks. Bluetooth.

Text Books:

1. *T.S.Rappaport, Wireless Communication Principles (2/e), Pearson, 2002.*
2. *A.F.Molisch, Wireless Communications, Wiley, 2005.*

Reference Books:

1. *P.MuthuChidambaraNathan, Wireless Communications, PHI, 2008.*
2. *W.C.Y.Lee, Mobile Communication Engineering. (2/e), McGraw- Hill, 1998.*
3. *A.Goldsmith, Wireless Communications, Cambridge University Press, 2005.*
4. *S.G.Glisic, Adaptive CDMA, Wiley, 2003.*

Course outcomes

At the end of the course student will be able

CO1: Apply the knowledge of basic communication systems and its principles.
CO2: Describe the cellular concept and analyze capacity improvement Techniques.
CO3: Mathematically analyze mobile radio propagation mechanisms.
CO4: Summarize diversity reception techniques.
CO5: Design Base Station (BS) parameters and analyze the antenna configurations.
CO6: Analyze and examine the multiple access techniques and its application.
CO7: Assess the latest wireless technologies.

Course Code	**:**	**ECPC23**
Course Title	**:**	**VLSI SYSTEMS**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECPC21**
Course Type	**:**	**PC**

Course Learning Objective

- To introduce various aspects of VLSI circuits and their design including testing**.**

Course Content

VLSI design methodology, VLSI technology- NMOS, CMOS and BICMOS circuit fabrication. Layout design rules. Stick diagram. Latch up.

Characteristics of MOS and CMOS switches. Implementation of logic circuits using MOS and CMOS technology, multiplexers and memory, MOS transistors, threshold voltage, MOS device design equations. MOS models, small-signal AC analysis. CMOS inverters, propagation delay of inverters, Pseudo NMOS, Dynamic CMOS logic circuits, power dissipation.

Programmable logic devices- anti fuse, EPROM and SRAM techniques. Programmable logic cells. Programmable inversion and expander logic. Computation of interconnect delay, Techniques for driving large off-chip capacitors, long lines, Computation of interconnect delays in FPGAs Implementation of PLD, EPROM, EEPROM, static and dynamic RAM in CMOS.

An overview of the features of advanced FPGAs, IP cores, Soft core processors, Various factors determining the cost of a VLSI, Comparison of ASICs, FPGAs , PDSPs and CBICs . Fault tolerant VLSI architectures

VLSI testing -need for testing, manufacturing test principles, design strategies for test, chip level and system level test techniques.

Text Books

1. *N. H. E. Weste, D.F. Harris, "CMOS VLSI design", (3/e), Pearson , 2005.*
2. *J. Smith, "Application Specific Integrated Circuits, Pearson", 1997.*

Reference Books

1. *M.M.Vai, "VLSI design", CRC Press, 2001.*
2. *Pucknell & Eshraghian, "Basic VLSI Design", PHI, (3/e), 2003.*
3. *Uyemura, "Introduction to VLSI Circuits and Systems", Wiley, 2002.*

Course outcomes

At the end of the course student will be able

CO1: Describe the techniques used for VLSI fabrication, design of CMOS logic circuits, switches and memory

CO2: Describe the techniques used the design of CMOS logic circuits, switches and memory in VLSI

CO3: Generalize the design techniques and analyze the characteristics of VLSI circuits such as area, speed and power dissipation

CO4: Explain and compare the architectures for FPGA, PAL and PLDs and evaluate their characteristics such as area, power dissipation and reliability

CO4: Use the advanced FPGAs to realize Digital signal processing systems

CO5: Describe the techniques for fault tolerant VLSI circuits

CO6: Explain and compare the techniques for chip level and board level testing

Course Code	**:**	**ECPC24**
Course Title	**:**	**RF AND MICROWAVE ENGINEERING**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECPC16**
Course Type	**:**	**PC**

Course Learning Objective

- To impart knowledge on basics of microwave electron beam devices and their applications in X band frequency and introduces the essential Microwave Circuit Theory and the design aspects of Microwave Integrated Circuit components.

Course Content

Limitations of Conventional tubes, two cavity Klystron Amplifier, Velocity modulation and Bunching Process, Reflex klystron oscillator –Multi cavity Klystron-Travelling Wave Tube amplifier- Magnetron Working principle and modes of Operation.

Two port Network theory- Scattering Matrix formulation- Passive microwave devices: E and H junction-hybrid junctions, terminations, bends, corners, attenuators, phase changers, directional couplers, Circulator, Isolator

Transferred Electron and Avalanche Devices: Gunn Diode, read diode, IMPATT, TRAPATT and BARIT

Design and Realization of MIC Components: Basics of Micro strip and Strip line – 3 dB Hybrid Design, Rat Race Coupler, Power Dividers

Microwave Measurements: Introduction to microwave Bench Set-up, Frequency, Wavelength, VSWR and Impedance Measurement. Network Analyzer, Spectrum analyzer.

Text Books

1. *I.J.Bahl & P.Bhartia, "Microwave Solid state Circuit Design", Wiley, 2003.*
2. *S.Y.Liao, "Microwave Devices and Circuits (3/e)", PHI, 2005*
3. *D.M.Pozar, "Microwave Engineering (2/e)", Wiley, 2004.*

Reference Books

1. *A. Das, "Microwave Engineering", Tata McGraw Hill, 2000*
2. *B.Bhat, S. K. Koul,"Stripline like transmission lines for Microwave Integrated Circuits", New age International Pvt.Ltd. Publishers 2007.*

Course outcomes

At the end of the course student will be able

CO1: Apply the basic knowledge of waveguide and microwave resonator circuits.
CO2: Understand the methods used for generation and amplification of the microwave power.
CO3: Distinguish between the linear and cross field electron beam microwave tubes.
CO4: Learn the basics of S parameters and use them in describing the components
CO5: Expose to the Microwave Measurements Principle

Course Code	**:**	**ECPE10**
Course Title	**:**	**NETWORKS AND PROTOCOLS**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**PE**

Course Learning Objectives

- To get an understanding on the fundamentals of networks and issues involved.
- To acquire an understanding on the set of rules and procedures that mediates the exchange of information between communicating devices.

Course Content

Network Components, Topologies, Network hardware and software, Network Models: OSI Model & TCP/IP Protocol stack, HTTP FTP, SMTP, POP, SNMP, DNS, Socket programming with TCP and UDP.

Transport Layer services, UDP, TCP, SCTP, Principles of reliable data transfer, Flow control, Congestion Control, Quality of Service.

Network Layer services, Datagram and Virtual circuit service, DHCP, IPV4, IPV6, ICMP, Unicast routing protocols: DV, LS and Path vector routing, Multicast routing.

Data Link Layer services, Overview of Circuit and Packet switches, ARP, Data link control: HDLC & PPP, Multiple access protocols, Wireless LAN, Comparison wired and wireless LAN.

Network security threats, Cryptography, Security in the Internet: IP Security & Firewalls, Multimedia: Streaming stored video/ audio, RTP, Network Troubleshooting.

Text Books

1. *J.F.Kurose & K.W.Ross, "Computer Networking: A Top-Down Approach featuring the Internet", Pearson, 5th edition, 2010.*
2. *B.A. Forouzan," Data Communications & Networking", Tata McGraw- Hill, 4th edition, 2006*

Reference Books

1. *W.Stallings, "Data & Computer Communications", PHI, 9th edition, 2011.*
2. *W.Stallings, "Cryptography & Network Security", Pearson, 5th edition, 2011.*
3. *A.S.Tanenbaum & D.J. Wetherall, "Computer Networks", Pearson, 5th edition, 2014.*
4. *Recent literature in Networks and Protocols.*

Course outcomes

At the end of the course student will be able

CO1: Compare and examine, OSI and TCP/IP protocol stacks
CO2: Categorize services offered by all layers in TCP/IP protocol stack
CO3: Analyze a network under congestion and propose solutions for reliable data transfer
CO4: Examine the protocols operating at different layers of TCP/IP model
CO5: Assess the cryptographic techniques.
CO6: Manage a network and propose solutions under network security threats.

Course Code	**:**	**ECPE11**
Course Title	**:**	**Wireless Local Area Networks (WLAN)**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECPE10**
Course Type	**:**	**PE**

Course Objective: To expose students to wireless local area network standards, technologies, and operations with real-life traces to correlate with the concepts

Course Contents

WLAN Introduction and Basics - 802.11 protocol stack basics, RF spectrum of operations, unlicensed band usage, Types of networks and their usage, Role of Wi-Fi alliance. Exercises: Survey of WLAN products in consumer appliances.

Evolution of WLAN Layer. The ISM PHYs: FH, DS and HR/DS, basics ofOFDM design and parameters for WLAN, MIMO usage in WLAN, Throughput enahancements**,** Matlab Simulation of channel models and studying their characteristics,

CSMA/CA principles used for WLAN MAC, Details of MAC protocol, Medium reservation and hidden nodes, MAC Frame Aggregation and QoS in WLAN, Roaming, Throughput calculation.

Network Entry Process in WLAN, Security Evolution, Power save concepts, Throughput and performance of WLAN, Network tracking operations.

Sniffing WLAN Frames and analysis using open source tools, Inferring capabilities of APs and clients, Analysing network entry steps and debugging connection problems, Analysing Data transmission and debugging performance issues, Analysis of Roaming performance.

Text Books

1. *Eldad Perahia and Robert Stacey, Next Generation wireless LANS 802.11n and 802.11ac, 2nd edition, Cambridge University Press, 2013*
2. *Mathew Gast, 802.11 Wireless Networks: The Definitive Guide, 2nd Edition, OReily, 2009*

Reference Books

1. *Mathew Gast, 802.11n: A Survival Guide: Wi-Fi Above 100 Mbps, OReilly, 2012*
2. *Mathew Gast, 802.11ac: A Survival Guide: Wi-Fi at Gigabit and Beyond, OReilly, 2012*

Course Outcomes:

CO1: To understand basics of WLAN systems including standardizing bodies, unlicensed spectrum ranges, network types.

CO2: Appreciate physical layer challenges and solutions in 802.11 standards and be able to simulate channel conditions

CO3: Be able to explain MAC layer steps in WLAN along with the motivation and impacts on throughput and coexistence

CO4: Trace the steps followed in a typical WLAN network with a clear understanding of security, power save, and network entry procedures

CO5: Analyze real-life protocol traces under various conditions and correlate with the concepts learnt in the earlier sections.

Course Code	**:**	**ECPE12**
Course Title	**:**	**MICROPROCESSORS AND MICRO CONTROLLERS**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**PE**

Course Learning Objective

- This subject deals about the basics of 16-bit Microprocessor, 8-bit and 16-bit Micro controllers, their architectures, internal organization and their functions, peripherals, and interfacing.

Course Content

Microprocessor based personal computer system. Software model of 8086. Segmented memory operation. Instruction set. Addressing modes. Assembly language programming. Interrupts. Programming with DOS and BIOS function calls.

Hardware detail of 8086. Bus timing. Minimum Vs Maximum mode of operation. Memory interface. Parallel and serial data transfer methods. 8255 PPI chip. 8259 Interrupt controller. 8237 DMA controller.

Microcontroller. Von-Neumann Vs Harvard architecture. Programming model. Instruction set of 8051 Microcontroller. Addressing modes. Programming. Timer operation.

Mixed Signal Microcontroller: MSP430 series. Block diagram. Address space. On-chip peripherals - analog and digital. Register sets. Addressing Modes. Instruction set. Programming. FRAM Vs flash for low power and reliability.

Peripheral Interfacing using 8051 and Mixed signal microcontroller. Serial data transfer - UART, SPI and I2C. Interrupts. I/O ports and port expansion. DAC, ADC, PWM, DC motor, Stepper motor and LCD interfacing.

Text Books

1. *J.L.Antonakos, "An Introduction to the Intel Family of Microprocessors", Pearson, 1999.*
2. *M.A.Mazidi & J.C.Mazidi "Microcontroller and Embedded systems using Assembly & C (2/e)", Pearson Education, 2007.*

Reference Books

1. *John H. Davies, "MSP430 Microcontroller Basics", Elsevier Ltd., 2008*
2. *B.B. Brey, "The Intel Microprocessors, (7/e), Eastern Economy Edition", 2006.*
3. *K.J. Ayala, "The 8051 Microcontroller ", (3/e), Thomson Delmar Learning, 2004.*
4. *I. S. MacKenzie and R.C.W.Phan., "The 8051 Microcontroller. (4/e)", Pearson education, 2008.*

Course outcomes

At the end of the course student will be able to

CO1: recall and apply the basic concept of digital fundamentals to Microprocessor based personal computer system.
CO2: identify the detailed s/w & h/w structure of the Microprocessor.
CO3: illustrate how the different peripherals are interfaced with Microprocessor.
CO4: distinguish and analyze the properties of Microprocessors & Microcontrollers.
CO5: analyze the data transfer information through serial & parallel ports.

Course Code	**:**	**ECPE13**
Course Title	**:**	**COMPUTER ARCHITECTURE AND ORGANIZATION**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**PE**

Course Learning Objectives

- To understand how computers are constructed out of a set of functional units and how the functional units operate, interact, and communicate.
- To make the students to understand the concept of interfacing memory and various I/O devices to a computer system using a suitable bus system.

Course Content

Introduction: Function and structure of a computer, Functional components of a Computer, Interconnection of components, Performance of a computer.

Representation of Instructions: Machine instructions, Memory locations & Addresses, Operands, Addressing modes, Instruction formats, Instruction sets, Instruction set architectures - CISC and RISC architectures, Super scalar Architectures, Fixed point and floating point operations.

Basic Processing Unit: Fundamental concepts, ALU, Control unit, Multiple bus organization, Hardwired control, Micro programmed control, Pipelining, Data hazards, Instruction hazards, Influence on instruction sets, Data path and control considerations, Performance considerations.

Memory organization: Basic concepts, Semiconductor RAM memories, ROM, Speed - Size and cost, Memory Interfacing circuits, Cache memory, Improving cache performance, Memory management unit, Shared/Distributed Memory, Cache coherency in multiprocessor, Segmentation, Paging, Concept of virtual memory, Address translation, Secondary storage devices.

I/O Organization: Accessing I/O devices, Input/output programming, Interrupts, Exception Handling, DMA, Buses, I/O interfaces- Serial port, Parallel port, PCI bus, SCSI bus, USB bus, Firewall and Infinity band, I/O peripherals.

Text Books

1. *C.Hamacher Z. Vranesic S. Zaky and Manjikian, "Computer Organization and Embedded Systems", 6 th Edition, McGraw-Hill, 2012.*
2. *W. Stallings, "Computer Organization and Architecture - Designing for Performance", 8Th Edition, Prentice Hall of India, 2010.*

Reference Books

1. *B,Parhami, "Computer Architecture, From Microprocessors to Supercomputers," Oxford University Press, Reprint 2014.*
2. *J. L. Hennessy and D. A. Patterson, "Computer Architecture, A Quantitative Approach", 5 th Edition, Morgan Kaufmann,2012.*
3. *J .P. Hayes, "Computer Architecture and Organization", 3 rd Edition, McGraw-Hill, 1998.*
4. *Recent literature in Computer Architecture and Organization.*

Course outcomes

At the end of the course student will be able to

CO1: apply the basic knowledge of digital concept to the functional components of a Computer System.
CO2: analyze the addressing mode concepts and design the instruction set Architecture.
CO3: identify the functions of various processing units within the CPU of a Computer System.
CO4: analyze the function of the memory management unit and create suitable memory interface to the CPU.
CO5: recognize the need for recent Bus standards and I/O devices.

Course Code	**:**	**ECPE14**
Course Title	**:**	**EMBEDDED SYSTEMS**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**PE**

Course Learning Objectives

- To make the students to understand and program embedded systems using modern embedded processors.
- This course describes example embedded platforms, interfaces, peripherals, processors and operating systems associated with embedded systems, a comprehensive view of the software frame work being developed around embedded SOCs.

Course Content

Introduction to Embedded Computing: Characteristics of Embedding Computing Applications, Concept of Real time Systems, Challenges in Embedded System Design, Design Process. Embedded System Architecture: Instruction Set Architecture, CISC and RISC instruction set architecture, Basic Embedded Processor/Microcontroller Architecture (ATOM processor, Introduction to Tiva family etc.)

Designing Embedded Computing Platform: Bus Protocols, Bus Organization, Memory Devices and their Characteristics, Memory mapped I/O, I/O Devices, I/O mapped I/O, Timers and Counters, Watchdog Timers, Interrupt Controllers, Interrupt programming, GPIO control, Sensors, Actuators, A/D and D/A Converters, Need of low power for embedded systems, Mixed Signals Processing.

Programming Embedded Systems: Basic Features of an Operating System, Kernel Features, Real-time Kernels, Processes and Threads, Context Switching, Scheduling, Shared Memory Communication, Message-Based Communication, Real-time Memory Management, Dynamic Allocation, Device Drivers, Real-time Transactions and Files, Real-time OS (VxWorks, RT-Linux, Psos).

Network Based Embedded Applications: Embedded Networking Fundamentals, Layers and Protocols, Distributed Embedded Architectures, Internet-Enabled Systems, IoT overview and architecture, Interfacing Protocols (like UART, SPI, I2C, GPIB, FIREWIRE, USB,). Various wireless protocols and its applications: NFC, Zig Bee, Bluetooth, Bluetooth Low Energy, Wi-Fi. CAN. Overview of wireless sensor networks and design examples

Case studies: Programming in Embedded C, Embedded system design using Arduino, ATOM processors, Galileo and Tiva based embedded system applications.

Text Books

1. *Wayne Wolf, "Computers as Components- Principles of Embedded Computing System Design", Morgan Kaufmann Publishers, Second edition, 2008.*
2. *Barry Crowley, "Modern Embedded Computing", Morgan Kaufmann Publishers, 2012.*

Reference Books

1. *Lyla B. Das, "Embedded Systems –An Integrated Approach", Pearson, 2013.*
2. Marwedel Peter, "Embedded System Design, Kluwer Publications, 2004.
3. *C.M. Krishna, Kang G. Shin, "Real time systems", Mc- Graw Hill, 2010*
4. *Recent literature in* Embedded Systems.

Course outcomes

At the end of the course student will be able to

CO1: get an insight into the overall landscape and characteristics of embedded systems.
CO2: facilitate a comprehensive understanding of the overall platform architecture of modern embedded computing systems.
CO3: develop application software for embedded systems using the RTOS functions.
CO4: enable network connectivity of the embedded systems via a combination of wired and wireless network interfaces.
CO5: design and program embedded systems based on their applications.

Course Code	**:**	**ECPE15**
Course Title	**:**	**OPERATING SYSTEMS**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**PE**

Course learning Objective

- To expose the principles and practice of operating system design and to illustrate the current design practices using DOS and UNIX operating systems.

Course content

Types of operating systems, Different views of the operating system, Principles of Design and Implementation. The process and threads. System programmer's view of processes, Operating system's views of processes, Operating system services for process management. Process scheduling, Schedulers, Scheduling algorithms. Overview of Linux operating system.

Inter process synchronization, Mutual exclusion algorithms, Hardware support,Semaphores, Concurrent programming using semaphores.

Conditional critical regions, Monitors, Inter process communication: Messages, Pipes. Deadlocks: Characterization. Prevention .Avoidance .Detection and recovery. Combined approach to deadlock handling.

Contiguous allocation. Static and dynamic partitioned memory allocation. Segmentation. Non-contiguous allocation. Paging, Hardware support, Virtual Memory.

Need for files. File abstraction. File naming. File system organization. File system optimization. Reliability. Security and protection .I/O management and disk scheduling. Recent trends and developments.

Text Books

1. *Gary: Operating Systems- A modern Perspective, (2/e), Addison Wesley, 2000.*
2. *M.Milenkovic: Operating systems, Concepts and Design, McGraw Hill, 1992.*

Reference Books

1. *C. Crowley: Operating Systems, Irwin, 1997.*
2. *J.l. Peterson & A.S. Chatz: Operating System Concepts, Addison Wesley, 1985.*
3. *W. Stallings: Operating Systems, (2/e), Prentice Hall, 1995.*
4. *Mattuck,A., Introduction to Analysis,Prentice-Hall,1998.*
5. *Recent literature in Operating Systems.*

Course outcomes

At the end of the course student will be able

CO1:.Understand the different types of Operating systems and scheduling algorithms.
CO2: Understand the synchronization algorithms and semaphores.
CO3: Appreciate the inter process communication and dead lock handling.
CO4: Critically evaluate the different memory allocation techniques.
CO5: Appreciate the importance of file system organization, I/O management and disk scheduling.

Course Code	**:**	**ECPE16**
Course Title	**:**	**ARM SYSTEM ARCHITECTURE**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**PE**

Course learning Objective

- The objective of this course is to give the students a thorough exposure to ARM architecture and make the students to learn the ARM programming & Thumb programming models.

Course Content

RISC machine. ARM programmer's model. ARM Instruction Set. Assembly level language programming. Development tools.

ARM organization. ARM instruction execution. ARM implementation. ARM coprocessor interface. Flynn's Taxonomy, SIMD and Vector Processors, Vector Floating Point Processor (VFP), VFP and ARM interactions, vector operation.

Floating point architecture. Expressions. Conditional statements. Loops. Functions and procedures. Run time environment. Interrupt response. Interrupt processing. Interrupt Handling schemes, Examples of Interrupt Handlers.

Thumb programmer's model. Thumb Instruction set. Thumb implementation. AMBA Overview, Typical AMAB Based Microcontroller, AHB bus features, AHB Bus transfers, APB bus transfers and APB Bridge.

Memory hierarchy. Architectural support for operating system. Memory size and speed. Cache memory management. Operating system. ARM processor chips. Features of Raspberry Pi and its applications.

Text Books

1. *S. Furber, "ARM System Architecture", Addison-Wesley, 1996.*
2. *Sloss, D.Symes & C.Wright, "ARM system Developer's guide-Designing and Optimizing System Software", Elsevier.2005.*

Reference Books

1. *Technical reference manual for ARM processor cores, including Cortex, ARM 11, ARM 9 & ARM 7 processor families.*
2. *User guides and reference manuals for ARM software development and modelling tools. David Seal, ARM Architecture Reference Manual, Addison-Wesley.*
3. *The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors, Third Edition by Joseph Yiu, Elsevier 2015*
4. *Recent literature in ARM System Architecture.*

Course outcomes

At the end of the course student will be able to

CO1: understand the programmer's model of ARM processor and test the assembly level programming.

CO2: analyze various types of coprocessors and design suitable co-processor interface to ARM processor.

CO3: analyze floating point processor architecture and its architectural support for higher level language.

CO4: become aware of the Thumb mode of operation of ARM.

CO5: identify the architectural support of ARM for operating system and analyze the function of memory Management unit of ARM.

Course Code	**:**	**ECPE17**
Course Title	**:**	**STATISTICAL THEORY OF COMMUNICATION**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**PE**

Course Learning Objective

- The subject aims to make the students to understand the statistical theory of telecommunication, which are the basics to learn analog and digital telecommunication.

Course Content

Information measure. Discrete entropy. Joint and conditional entropies. Uniquely decipherable and instantaneous codes. Kraft-McMillan inequality. Noiseless coding theorem. Construction of optimal codes.

DMC. Mutual information and channel capacity. Shannon's fundamental theorem. Entropy in the continuous case. Shannon-Hartley law.

Binary hypothesis testing. Baye's, mini max and Neyman-Pearson tests. Random parameter estimation-MMSE, MMAE and MAP estimates. Non-random parameters – ML estimation.

Coherent signal detection in the presence of additive white and non-white Gaussian noise. Matched filter.

Discrete optimum linear filtering. Orthogonality principle. Spectral factorization. FIR and IIR Wiener filters.

Text Books

1. *R.B.Ash," Information Theory", Wiley, 1965.*
2. *M.D.Srinath, P.K.Rajasekaran & R.Viswanathan, "Statistical Signal Processing with Applications", PHI 1999.*

Reference Books

1. *H.V.Poor, "An Introduction to Signal Detection and Estimation, (2/e)", Spring Verlag.1994.*
2. *M.Mansuripur, "Introduction to Information Theory", Prentice Hall.1987.*
3. *J.G.Proakis, D G Manolakis, "Digital Signal Processing", (4/e), Pearson Education, 2007.*

Course outcomes

At the end of the course student will be able

CO1: show how the information is measured and able to use it for effective coding.
CO2: summarize how the channel capacity is computed for various channels.
CO3: use various techniques involved in basic detection and estimation theory to solve the problem.
CO4: summarize the applications of detection theory in telecommunication.
CO5: summarize the application of estimation theory in telecommunication.

Course Code	**:**	**ECPE18**
Course Title	**:**	**DIGITAL SIGNAL PROCESSORS AND APPLICATIONS**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECPC15**
Course Type	**:**	**PE**

Course Learning Objective

- To give an exposure to the various fixed point and floating point DSP architectures, to understand the techniques to interface sensors and I/O circuits and to implement applications using these processors.

Course Content

Fixed-point DSP architectures. Basic Signal processing system. Need for DSPs. Difference between DSP and other processor architectures. TMS320C54X, ADSP21XX, DSP56XX architecture details. Addressing modes. Control and repeat operations. Interrupts. Pipeline operation. Memory Map and Buses.

Floating-point DSP architectures. TMS320C3X, DSP96XX architectures. Cache architecture. Floating-point Data formats. On-chip peripherals. Memory Map and Buses.

On-chip peripherals. Hardware details and its programming. Clock generator with PLL. Serial port. McBSP. Parallel port. DMA. EMIF. I^2C. Real-time-clock (RTC). Watchdog timer.

Interfacing. Serial interface- Audio codec. Sensors - Humidity/temperature sensor, flow sensor, accelerometer, pulse sensor and finger print scanner. A/D and D/A interfaces. Parallel interface-Memory interface. RF transceiver interface – Wi-Fi and Zigbee modules.

DSP tools and applications. Implementation of Filters, DFT, QPSK Modem, Speech processing. Video processing, Videoencoding/Decoding. Biometrics. Machine Vision. High performance computing (HPC).

Text Books

1. *B.Venkataramani & M.Bhaskar, "Digital Signal Processor, Architecture, Programming and Applications",(2/e), McGraw- Hill,2010*
2. *S.Srinivasan & Avtar Singh, "Digital Signal Processing, Implementations using DSP Microprocessors with Examples from TMS320C54X", Brooks/Cole, 2004.*

Reference Books

1. *S.M.Kuo & W.S.S.Gan," Digital Signal Processors: Architectures, Implementations, and Applications", Printice Hall, 2004*
2. *C.Marven & G.Ewers, "A Simple approach to digital signal processing", Wiley Inter science, 1996.*
3. *R.A.Haddad & T.W.Parson, "Digital Signal Processing: Theory, Applications and Hardware", Computer Science Press NY, 1991.*

Course outcomes

At the end of the course student will be able

CO1: learn the architecture details of fixed point DSPs.
CO2: learn the architecture details of floating point DSPs
CO3: infer about the control instructions, interrupts, pipeline operations, memory and buses.
CO4: illustrate the features of on-chip peripheral devices and its interfacing with real time application devices.
CO5: learn to implement the signal processing algorithms and applications in DSPs

Course Code	**:**	**ECPE19**
Course Title	**:**	**HIGH SPEED SYSTEM DESIGN**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**PE**

Course Learning Objective

- To expose the students to all aspects of electronic packaging including electrical, thermal, mechanical and reliability issues.

Course Content

Functions of an Electronic Package, Packaging Hierarchy, IC packaging: MEMS packaging, consumer electronics packaging, medical electronics packaging, Trends, Challenges, Driving Forces on Packaging Technology, Materials for Microelectronic packaging, Packaging Material Properties, Ceramics, Polymers, and Metals in Packaging, Material for high density interconnect substrates

Overview of Transmission line theory, Clock Distribution, Noise Sources, power Distribution, signal distribution, EMI; crosstalk and non-ideal effects; signal integrity: impact of packages, via, traces, connectors; non-ideal return current paths, high frequency power delivery, simultaneous switching noise; system-level timing analysis and budgeting; methodologies for design of high speed buses; radiated emissions and minimizing system noise.

Electrical Anatomy of Systems Packaging, Signal Distribution, Power Distribution, Electromagnetic Interference, Design Process Electrical Design: Interconnect Capacitance, Resistance and Inductance fundamentals; Transmission Lines , Clock Distribution, Noise Sources, power Distribution, signal distribution, EMI, Digital and RF Issues. Processing Technologies, Thin Film deposition, Patterning, Metal to metal joining.

IC Assembly – Purpose, Requirements, Technologies, Wire bonding, Tape Automated Bonding, Flip Chip, Wafer Level Packaging , reliability, wafer level burn – in and test.Single chip packaging : functions, types, materials processes, properties, characteristics, trends.Multi chip packaging : types, design, comparison, trends. Passives: discrete, integrated, and embedded –encapsulation and sealing: fundamentals, requirements, materials, processes

Printed Circuit Board: Anatomy, CAD tools for PCB design, Standard fabrication, Micro via Boards. Board Assembly: Surface Mount Technology, Through Hole Technology, Process Control and Design challenges. Thermal Management, Heat transfer fundamentals, Thermal conductivity and resistance, Conduction, convection and radiation – Cooling requirements.

Reliability, Basic concepts, Environmental interactions. Thermal mismatch and fatigue – failures – thermo mechanically induced – electrically induced – chemically induced. Electrical Testing: System level electrical testing, Interconnection tests, Active Circuit Testing, Design for Testability.

Text Book

1. *Tummala, Rao R., Fundamentals of Microsystems Packaging, McGraw Hill, 2001*
2. *Howard Johnson , Martin Graham, High Speed Digital Design: A Handbook of Black Magic, Prentice Hall, 1993*

Reference Books

1. *Blackwell (Ed), The electronic packaging handbook, CRC Press, 2000.*
2. *Tummala, Rao R, Microelectronics packaging handbook, McGraw Hill, 2008.*
3. *Bosshart, Printed Circuit Boards Design and Technology,TataMcGraw Hill, 1988.*
4. *R.G. Kaduskar and V.B.Baru, Electronic Product design, Wiley India, 2011*
5. *R.S.Khandpur, Printed Circuit Board, Tata McGraw Hill, 2005*
6. *Recent literature in Electronic Packaging*.

Course outcomes

At the end of the course student will be able

CO1: Design of PCBs which minimize the EMI and operate at higher frequency.

CO2: Enable design of packages which can withstand higher temperature, vibrations and shock.

Course Code	**:**	**ECPE20**
Course Title	**:**	**DIGITAL SPEECH PROCESSING**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECPC15**
Course Type	**:**	**PE**

Course learning Objective

- The purpose of this course is to explain how DSP techniques could be used for solving problems in speech communication.

Course content

Speech production model-1D sound waves-functional block of the Vocal tract model –Linear predictive co- efficient (LPC) -Auto-correlation method-Levinson-Durbin algorithm-Auto-co-variance method-Lattice structure-Computation of Lattice co-efficient from LPC-Phonetic Representation of speech-Perception of Loudness - Critical bands – Pitch perception – Auditory masking.

Feature extraction of the speech signal: Endpoint detection-Dynamic time warping- Pitch frequency estimation: Autocorrelation approach- Homomorphic approach-Formant frequency estimation using vocal tract model and Homomorphic approach-Linear predictive co-efficient -Poles of the vocal tract-Reflection co-efficient-Log Area ratio.

Cepstrum- Line spectral frequencies- Functional blocks of the ear- Mel frequency cepstral co-efficient- Spectrogram-Time resolution versus frequency resolution-Discrete wavelet transformation.

Pattern recognition for speech detection: Back-propagation Neural Network-Support Vector Machine-Hidden Markov Model (HMM)-Gaussian Mixture Model(GMM) -Unsupervised Learning system: K-Means and Fuzzy K-means clustering - Kohonen self-organizing map-Dimensionality reduction techniques: Principle component analysis (PCA), Linear discriminate analysis (LDA), Kernel-LDA (KLDA), Independent component analysis(ICA).

Non-uniform quantization for Gaussian distributed data- Adaptive quantization-Differential pulse code modulation- Code Exited Linear prediction (CELP)-Quality assessment of the compressed speech signal Text to Speech (TTS) analysis –Evolution of speech synthesis systems-Unit selection methods - TTS Applications.

Text Books

1. *L.R.Rabiner and R.W.Schafer," Introduction to Digital speech processing", now publishers USA,2007*
2. *E.S.Gopi,"Digital speech processing using matlab", Springer, 2014.*

Reference Books

1. *L.R.Rabiner and R.W.Schafer,"Digital processing of speech signals", PrenticeHall,1978*
2. *T.F.Quatieri, "Discrete-time Speech Signal Processing", Prentice-Hall, PTR,2001*
3. *L.Hanzaetal, "Voice Compression and Communications", Wiley/ IEEE, 2001.*
4. *Recent literature in Digital speech processing.*

Course outcomes

At the end of the course student will be able

CO1: illustrate how the speech production is modeled

CO2: summarize the various techniques involved in collecting the features from the speech signal in both time and frequency domain

CO3: summarize the functional blocks of the ear

CO4: compare the various pattern recognition techniques involved in speech and speaker detection

CO5: summarize the various speech compression techniques

Course Code	**:**	**ECPE21**
Course Title	**:**	**DIGITAL IMAGE PROCESSING**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**PE**

Course learning Objective

- To treat the 2D systems as an extension of 1D system design and discuss techniques specific to 2D systems.

Course content

Linearity and space-invariance. PSF, Discrete images and image transforms, 2-D sampling and reconstruction, Image quantization, 2-D transforms and properties.

Image enhancement- Histogram modeling, equalization and modification. Image smoothing, Image crispening. Spatial filtering, Replication and zooming, Generalized cepstrum and homomorphic filtering.

Image restoration- image observation models. Inverse and Wiener filtering. Filtering using image transforms. Constrained least-squares restoration. Generalized inverse, SVD and interactive methods. Recursive filtering. Maximum entropy restoration. Bayesian methods.

Image data compression- sub sampling, coarse quantization and frame repetition. Pixel coding - PCM, entropy coding, run length coding Bit-plane coding. Predictive coding. Transform coding of images. Hybrid coding and vector DPCM. Inter-frame hybrid coding.

Image analysis- applications, Spatial and transform features. Edge detection, boundary extraction, AR models and region representation. Moments as features. Image structure .Morphological operations and transforms. Texture. Scene matching and detection. Segmentation and classification.

Text Books

1. *A.K. Jain, "Fundamentals of Digital Image Processing", PHI, 1995.*
2. *R.C.Gonzalez & R.E. Woods," Digital Image Processing", (2/e), Pearson, 2002.*

Reference Books

1. *J.C. Russ, "The Image Processing Handbook", (5/e), CRC, 2006.*
2. *E.S.Gopi, "Digital Image processing using Matlab", Scitech publications, 2006.*
3. *Recent literature in Digital Image processing.*

Course outcomes

At the end of the course student will be able
CO1: analyze the need for image transforms, types and their properties.
CO2: become skilled at different techniques employed for the enhancement of images both in spatial and frequency domain.
CO3: explore causes for image degradation and to teach various restoration techniques.
CO4: evaluate the image compression techniques in spatial and frequency domain.
CO5: gain knowledge of feature extraction techniques for image analysis and recognition.

Course Code	**:**	**ECPE22**
Course Title	**:**	**PATTERN RECOGNITION**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**PE**

Course learning Objective

- The subject aims to make the students to understand the mathematical approach for pattern recognition.

Course content

Polynomial curve fitting – The curse of dimensionality - Decision theory - Information theory - The beta distribution - Dirichlet distribution-Gaussian distribution-The exponent family: Maximum likelihood and sufficient statistics -Non-parametric method: kernel-density estimators - Nearest neighbourmethods.

Linear models for regression and classification: Linear basis function models for regression - Bias variance decomposition-Bayesian linear regression-Discriminant functions - Fisher's linear discriminant analysis (LDA) - Principal Component Analysis (PCA) - Probabilistic generative model - Probabilistic discriminative model.

Kernel methods: Dual representations-Constructing kernels-Radial basis function networks-Gaussian process-Maximum margin classifier (Support Vector Machine) –Relevance Vector Machines-Kernel-PCA, Kernel-LDA.

Mixture models: K-means clustering - Mixtures of Gaussian - Expectation-Maximization algorithm-Sequential models: Markov model, Hidden-Markov Model (HMM) - Linear Dynamical Systems(LDS).

Neural networks: Feed- forward Network functions-Network training - Error Back propagation - The Hessian Matrix - Regularization in Neural Network - Mixture density networks – Bayesian Neural Networks

TextBooks

1. *C.M.Bishop,"Pattern recognition and machinelearning",Springer,2006*
2. E.S.Gopi, "Pattern recognition and Computational intelligence using matlab, Transactions on computational science and computational intelligence, Springer, 2019

ReferenceBooks

1. Sergious Thedorodis ,Konstantinos Koutroumbas, Pattern recognition, Elsevier, Fourth edition,2009
2. *Richard O.Duda, Peter.E.Hart, David G.Stork, "Pattern classification", Wiley, Second edition,2016*
3. *Recent literature in the related topics*

COURSEOUTCOMES

Students are able to

CO1: summarize the various techniques involved in patternrecognition
CO2: identify the suitable pattern recognition techniques for the particular applications.
CO3: categorize the various pattern recognition techniques into supervised and unsupervised.
CO4: summarize the mixture models based pattern recognitiontechniques
CO5: summarize the artificial neural network based pattern recognitiontechniques

Course Code	**:**	**ECPE23**
Course Title	**:**	**DISPLAY SYSTEMS**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECPC13**
Course Type	**:**	**PE**

Course learning Objective

- To expose the students to the basics of the display systems and to illustrate the current design practices of the display systems.

Course content

Introduction to displays. Requirements of displays. Display technologies, CRT, Flat panel and advanced display technologies. Technical issues in displays.

Head mounted displays. Displays less than and greater than 0.5 m diagonal. Low power and light emitting displays.

Operation of TFTs and MIMS. LCDs, Brightness. Types of LCD displays.

Emissive displays, ACTFEL, Plasma display and Field emission displays, operating principle and performance.

Types of Displays: 3D, HDTV, LED, Touch screen.

Text Books

1. *L.W. Mackonald & A.C. Lowe, Display Systems, Design and Applications, Wiley, 2003.*
2. *E.H. Stupp &M. S. Brennesholtz, Projection Displays, Wiley,1999*

Reference Book

1. *Peter A. Keller, Electronic Display Measurement: Concepts, Techniques, and Instrumentation, Wiley-Inter science, 1997.*
2. *Recent literature in Display Systems.*

Course outcomes

At the end of the course student will be able
CO1: appreciate the technical requirement of different types of displays systems
CO2: analyze the various low power lighting systems
CO3: understand the operation of TFTs and LCD displays.
CO4: analyze the various kinds of emissive displays
CO5: critically evaluate the recent advancements in the displays device technology.

Course Code	**:**	**ECPE24**
Course Title	**:**	**INTERNET OF THINGS**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**CSIR11, ECPE12, C/C++ and Python Programming skills**
Course Type	**:**	**PE**

Course Learning Objective

- To understand basics of an IOT System, IoT sensors, IoT hardware and communication protocols, data storage, data analysis and use them for real time IoT enabled domains.

Course Content

Introduction to IoT and IoT levels : Functional blocks of an IoT system (Sensors, Data Ingress, Data Aggregation Point Communication point back to the cloud, Analysis, Decision making, Actuation) Basic of Physical and logical design of IoT (IoT protocols, communication models) IoT enabled domains (Home automation, Smart cities, environment monitoring, renewable energy, agriculture, industry, healthcare, marketing and management) M2M, Difference between IoT, Embedded Systems and M2M, Industry 4.0 concepts.

IoT sensors and hardware : Passive and active sensors, differences, Different kinds of sensors (Temperature, humidity, pressure, obstacle, water flow, accelerometer, colour, gyro, load cell, finger print, motion, ultrasonic distance, magnetic vibration, eye blink, hear beat, PPG, glucose, body position, blood pressure), Multi-sensors, Pre-processing (sampling, filtering, ADC, size of data, local memory, compression), IoT front end hardware (Raspberry Pi, Arduino, Galileo, beagle bone equivalent platforms)

Introduction to IoT protocols : Infrastructure (6LowPAN, IPv4/IPv6, RPL), Identification (EPC, uCode, IPv6, URIs), Communication/ Transport (Wi-Fi, Bluetooth, ZigBee, LPWAN), Data Protocols (MQTT, CoAP, AMQP, Websocket, Node)

IoT Cloud and data analytics : Collecting data from sensors,Data Ingress, Cloud storage, IoT cloud platforms (Amazon AWS, Microsoft Azure, Google APIs), Data analytics for IoT, Software and management tool for IoT, Dashboard design

IoT architectures with case studies : Business models for IoT, smart cities, agriculture, healthcare, industry. Case studies/Mini projectsfor the real time IoT applications.

Text Books

1. Arshdeep Bahga, Vijay Madisetti, "Internet of Things – A hands-on approach", Universities Press, 2015.

Reference Books

1. *Raj kamal, Internet of Things, Architecture and Design Principles, McGraw-Hill, 2017*
2. *Manoel Carlos Ramon, "Intel® Galileo and Intel® Galileo Gen 2: API Features and Arduino Projects for Linux Programmers", Apress, 2014.H.Gerez, "Algorithms for VLSI Design Automation", John Wiley, 1999.*

1. *Marco Schwartz, "Internet of Things with the Arduino Yun", Packt Publishing, 2014..*

COURSEOUTCOMES

Students are ableto

CO1: understand basic premise of an IOT System
CO2 : be familiar with the sensors available for IoT applications
CO3 : learn the front-end hardware platforms and communication protocols for IoT.
CO4 : understand cloud storage, data analysis and management
CO5 : usage for real time IoT enabled domains

Course Code	**:**	**ECPE26**
Course Title	**:**	**COGNITIVE RADIO**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECPC15**
Course Type	**:**	**PE**

Course learning Objective

- This subject introduces the fundamentals of multi rate signal processing and cognitive radio.

Course content

Filter banks-uniform filter bank. Direct and DFT approaches. Introduction to ADSL Modem. Discrete multi-tone modulation and its realization using DFT.QMF. STFT. Computation of DWT using filter banks.
DDFS- ROM LUT approach. Spurious signals, jitter. Computation of special functions using CORDIC. Vector and rotation mode of CORDIC. CORDIC architectures.

Block diagram of a software radio. Digital down converters and demodulators Universal modulator and demodulator using CORDIC. Incoherent demodulation - digital approach for I and Q generation, special sampling schemes. CIC filters. Residue number system and high speed filters using RNS. Down conversion using discrete Hilbert transform. Under sampling receivers, Coherent demodulation schemes.

Concept of Cognitive Radio, Benefits of Using SDR, Problems Faced by SDR, Cognitive Networks, Cognitive Radio Architecture. Cognitive Radio Design, Cognitive Engine Design,

A Basic OFDM System Model, OFDM based cognitive radio, Cognitive OFDM Systems, MIMO channel estimation, Multi-band OFDM, MIMO-OFDM synchronization and frequency offset estimation. Spectrum sensing to detect Specific Primary System, Spectrum Sensing for Cognitive OFDMA Systems.

Text Books

1. *J. H. Reed, "Software Radio", Pearson, 2002.*
2. *U. Meyer – Baese, "Digital Signal Processing with FPGAs", Springer, 2004.*

Reference Books

1. *H. Arslan "Cognitive Radio, Software Defined Radio and Adaptive Wireless Systems", University of South Florida, USA, Springer, 2007.*
2. *S. K. Mitra, "Digital Signal processing", McGrawHill,1998*
3. *K.C.Chen, R.Prasad, "Cognitive Radio Networks", Wiley, 2009-06-15.*
4. *T.W.Rondeau, C.W.Bostian, "Artificial Intelligence in Wireless Communications",2009.*
5. *Tusi, "Digital Techniques for Wideband receivers", Artech House, 2001.*
6. *T. DarcChiueh, P. Yun Tsai," OFDM baseband receiver design for wireless communications", Wiley,2007*
7. *Recent literature in Cognitive Radio*

Course outcomes

At the end of the course student will be able

CO1: gain knowledge on multi-rate systems.

CO2: develop the ability to analyze, design, and implement any application usingFPGA.

CO3: be aware of how signal processing concepts can be used for efficient FPGA based system design.

CO4: understand the rapid advances in Cognitive radio technologies.

CO5: explore DDFS, CORDIC and its application.

Course Code	**:**	**ECPE27**
Course Title	**:**	**MULTIMEDIA COMMUNICATION TECHNOLOGY**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECPC15**
Course Type	**:**	**PE**

Course learning Objective

- To made the students to understand various encoding and decoding techniques of audios and videos in multimedia systems.

Course content

Components of multimedia system, Desirable features, Applications of multimedia systems, Introduction to different types, Multimedia storage device.

Digital audio representation and processing-time domain and transform domain representations. Coding standards, transmission and processing of digital audio. Musical instrument synthesizers.

Still image coding-JPEG. Discrete cosine Transform. Sequential and Progressive DCT based encoding algorithms, lossless coding, and hierarchical coding. Basic concepts of discrete wavelet transform coding and embedded image coding algorithms. Introduction to JPEG2000.

Feature of MPEG 1, structure of encoding and decoding process, MPEG 2 enhancements, and different blocks of MPEG video encoder.

Content based video coding-overview of MPEG 4 video, motion estimation and compensation. Different coding techniques and verification models. Block diagram of MPEG 4 video encoder and decoder. An overview of H261 and H263 video coding techniques.

Text Books

1. *Y.Q.Shi & H.Sun, Image and Video Compression for Multimedia Engineering, CRC Press, 2000.*
2. *S.V.Raghavan & S,K,Tripathi, Networked Multimedia Systems, Prentice-Hall,1998.*

Reference Books

1. *J.F.K.Buford, Multimedia Systems, Pearson, 2000.*
2. *Recent literature in Multimedia Communication Technology.*

Course outcomes

At the end of the course student will be able

CO1: analyze various components of the multimedia systems and its storage devices.
CO2: appreciate the different coding standards for the digital audio and musical synthesizers.
CO3: understand the various types of DCT based image encoding algorithms
CO4: understand the encoding and decoding process of the MPEG standards
CO5: analyze the different content based video processing techniques.

Course Code	**:**	**ECPE28**
Course Title	**:**	**COMMUNICATION SWITCHING SYSTEMS**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECPC18**
Course Type	**:**	**PE**

Course learning Objective

- To understand the working principles of switching systems from manual and electromechanical systems to stored program control systems.

Course content

Basic elements of communication network. Switching systems. Signaling and signaling functions.

Digital telephone network. TDM Principles. PCM primary multiplex group. Plesiochronous digital hierarchy. Synchronous digital hierarchy. Echo cancellers.

Digital transmission and multiplexing. Synchronous versus Asynchronous transmission. Line coding. Error performance. TDM. Framing, TDM loops and rings.

Space division switching. Multiple-stage switching. Design examples. Switching matrix control. Time division switching. Multiple-stage time and spaces witching.

Timing recovery. Jitter. Network synchronization. Digital subscriber access-ISDN. ADSL. HFC. Traffic analysis.

Text Books

1. *J.C. Bellamy, "Digital Telephony", Wiley, 3rd edition, 2011.*
2. *J.E. Flood, "Telecommunications Switching, Traffic and Networks" Pearson,1st edition,2012*

Reference Books

1. *T.Viswanathan, "Telecommunication Switching Systems and Networks", PHI, 2006.*
2. *E.Keiser & E.Strange, "Digital Telephony and Network Integration", Springer, 2nd edition, 1995.*
3. *R. L.Freeman, "Fundamentals of Telecommunications", John Wiley and Sons, 2ndedition, 1999.*
4. *Recent literature in Communication Switching Systems.*

Course outcomes

At the end of the course student will be able

CO1: explain the working principle of switching systems involved in telecommunication switching
CO2: assess the need for voice digitization and T Carrier systems
CO3: compare and analyze Line coding techniques and examine its error performance
CO4: design multi stage switching structures involving time and space switching stages
CO5: analyze basic telecommunication traffic theory

Course Code	**:**	**ECPE29**
Course Title	**:**	**BROADBAND ACCESS TECHNOLOGIES**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECPC18 & ECPC19**
Course Type	**:**	**PE**

Course learning Objective

- To impart fundamentals and latest technologies related to the design of broadband last mile-Access technologies for multimedia communication

Course content

Wired access technologies using Phone line modem, ISDN modem. Comparison-Cable, DSL, fiber and wireless access technologies.

Last mile copper access, Flavors of Digital subscriber lines, DSL deployment, Common local loop impairments, discrete multi-tone modulation, VDSL deployment and frequency plans. Standards for XDSL and comparison.

Last mile HFC access, Cable modems. Modulation schemes, DOCSIS. Standards- comparison, physical and MAC layer protocols for HFC networks, ATM and IP-centric modem. Switched digital video.

Fiber access technologies and architectures. ATM passive optical networks, Upstream and downstream transport, Frame format, Ethernet passive optical network, Gigabit passive optical networks.

Survey on emerging broadband wireless access technologies. LMDS,MMDS,WIMAX and WIFI, Satellite technologies serving as last mile solutions, Wireless LAN, Wireless personal area networking, 3G and 4G wireless systems.

Text Books

1. *N.Jayant, "Broadband last mile"-Taylor and Francisgroup,2005*
2. *N.Ransom & A.A. Azzam, "Broadband Access Technologies", McGraw Hill, 1999.*

Reference Books

1. *M.P. Clarke, "Wireless Access Network", Wiley, 2000.*
2. *T.Starr, M.Sorbara, J.M.Cioffi and P.J.Silverman,"DSLadvances",PrenticeHall,2002*
3. *S. Mervana & C.Le, "Design and Implementation of DSL-based Access Solutions", Cisco Press, 2001.*
4. *W. Vermillion, "End-to-End DSL Architecture", Cisco Press, 2003.*
5. *DOCSIS 2.0 "Radio frequency interface specification"www.cablemodem.com*
6. *ITU-T Rec., G.983.1 "Broadband Optical Access systems based on Passive OpticalNetworks",1998*
7. *Recent literature in Broadband Access Technologies.*

Course outcomes

At the end of the course student will be able

CO1: recall and identify the basics of broadband technology systems and differentiate the differences between the various wired and wireless technology system

CO2: illustrate the aspects of last mile data transport on copper wire networks and flavors of DSL

CO3: summarize the versions of cable network standard and MAC protocols for HFC networks

CO4: distinguish the cost effective broadband services for residential users and ATM based and Ethernet based passive optical networks

CO5: outline the types of broadband wireless access technologies and their characteristics.

Course Code	**:**	**ECPE30**
Course Title	**:**	**MICROWAVE COMPONENTS AND CIRCUITS**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECPC16**
Course Type	**:**	**PE**

Course Learning Objective

- The subject introduces the essential Microwave Circuit Theory and the design aspects of Microwave Integrated Circuit components.

Course Content

Scattering matrix formulation. Passive microwave devices; terminations, bends, corners, attenuators, phase changers, directional couplers and hybrid junctions. Basics and design considerations of Microstrip line, strip line, coplanar waveguide, Slot line and Fin line.

Microwave measurements; frequency, wavelength, VSWR. Impedance determination. S-parameter measurements. Network analyzer.

Microwave network parameters. Basic circuit elements for microwaves. Transmission line sections and stubs. Richard transformation. Kuroda identities.

MIC filter design. Low pass to high pass, band pass and band stop transformations. Realization using micro strip lines and strip lines.

Design and realization of MIC components.3 dB hybrid design. Rat race Hybrid Ring, Backward wave directional coupler, power divider; realization using micro strip lines and strip lines.

Text Books

1. *I.J.Bahl & P.Bhartia, "Microwave Solid state Circuit Design", Wiley, 2003.*
2. *D.M.Pozar, "Microwave Engineering (2/e)", Wiley, 2004.*

Reference Books

1. *A. Das, "Microwave Engineering", Tata McGraw Hill, 2000*
2. *B.Bhat, S. K. Koul,"Stripline like transmission lines for Microwave Integrated Circuits", New age International Pvt.Ltd. Publishers 2007.*
3. *G. Matthaei, E.M.T. Jones , L. Young , George Matthaei, Leo Young , George L. Matthaei "Microwave filters, Impedance Matching Network, Coupling Structures (Updated)",Hardcover, 1,096 Pages, Published 1980 by Artech House Publishers ISBN-13: 978-0-89006-099-5, ISBN: 0-89006-099-1*

Course outcomes

At the end of the course student will be able

CO1: Learn the basics of S parameters and use them in describing the components
CO2: Expose to the Microwave Measurements Principle
CO3: Realize the importance of the theory of Microwave circuit theory.
CO4: Work out the complete design aspects of various M.I.C. Filters
CO5: Confidently design all M.I.C. components to meet the industry standard

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Course Code	**:**	**ECPE31**
Course Title	**:**	**FIBER OPTIC COMMUNICATION**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECPC12 &ECPC18**
Course Type	**:**	**PE**

Course Learning Objective

- To expose the students to the basics of signal propagation through optical fibers, fiber impairments, components, devices and system design.

Course Content

Optical Fibers: Structure, Wave guiding. Step-index and Graded index optical fibers. Modal analysis. Classification of modes. Single Mode Fibers.

Pulse dispersion. Material and Waveguide dispersion. Polarization Mode Dispersion. Absorption, scattering and bending losses. Dispersion Shifted Fibers, Dispersion Compensating Fibers.

Optical sources: LEDs and Laser Diodes. Optical Power Launching and Coupling. Source to Fiber coupling, Fiber to Fiber joints. Misalignments. Schemes for coupling improvement.

Optical detectors: PIN and Avalanche photodiodes, Photo detector noise, Optical receivers. Digital link design: Power budget and Rise time budget. Attenuation and Dispersion limit.

WDM Concepts. Optical Amplifiers: EDFA. Nonlinear effects: Self Phase Modulation, Nonlinear Schrodinger Equation. Optical Soliton.

Text Books

1. *G. Keiser, "Optical Fiber Communications (5/e)", McGraw Hill, 2013.*
2. *A. Ghatak & K. Thygarajan, "Introduction to Fiber Optics", Cambridge, 1999.*

Reference Books

1. *G. P. Agarwal, "Fiber Optic Communication Systems", (4/e), Wiley, 2010.*
2. *M. M. K. Liu, "Principles and Applications of Optical Communications", Tata McGraw Hill, 2010.*
3. *A. Selvarajan, S. Kar and T. Srinivas, "Optical Fiber Communication Principles and Systems", Tata McGraw Hill, 2006.*

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Course outcomes

At the end of the course student will be able

CO1: Recognize and classify the structures of Optical fiber and types.
CO2: Discuss the channel impairments like losses and dispersion.
CO3: Classify the Optical sources and calculate various coupling losses.
CO4: Classify detectors and to design a fiber optic link.
CO5: Familiar with concepts of WDM, optical amplifiers and Soliton Propagation.

Course Code	**:**	**ECPE32**
Course Title	**:**	**DIGITAL SIGNAL PROCESSING FOR WIRELESS COMMUNICATION**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECPC15**
Course Type	**:**	**PE**

Course Learning Objectives

- The subject aims to make the students to understand the usage of various signal processing techniques used for wireless communication

Course Content

Mathematical model of the Time-varying wireless channel: Multi-path model, Coherence time and Doppler spread, Coherence frequency and Delay spread. Relationship between the time-varying impulse response of the Base band and Bandpass Transmission. Discrete Complex Base band time varying channel model for wireless communication. Computation of probability of error for Flat fading Rayleigh channel, Flat fading Rician model and single tap channel with known filter co-efficient.

Autocorrelation and the Spectral density computation of base band and the band pass signal. Sampling and reconstruction of W.S.S. random process. Spectral density computation for PSK, QPSK, FSK and MSK. Relationship between Base band and band pass random process using Hilbert transformation. Periodogram, Barlett method, Welch, Blackman and Tuckey methods of estimating spectrum of the modulated signal.

Multiple input Multiple output (MIMO) System model, Zero forcing receiver, LMMSE receiver, Matched filter receiver. Optimal precoding and combining, Spatial multiplexing using Decoupling of MIMO system. Massive MIMO, Power scaling, Orthogonality, Multi-cell Multi user MIMO, Pilot contamination and Rate scaling.

Orthogonal Frequency division Multiplexing (OFDM) Multicarrier modulation (MCM) , MCM transmission/Received signal, MCM-IFFT/FFT Processing, MCM-Cyclic prefix, Spectrum of OFDM transmission, MIMO-OFDM System model, BER of OFDM and MIMO-OFDM

5G Technology: Non-orthgonal multiple access, Spatial Modulation, Filter bank multi-carrier systems (FBMC), FBMC-OQAM System model, MIMO-FBMC Signal processing, Full Duplex Radio, Self-interference, Hybrid cancellation, mm wave MIMO Channel Modeling and Estimation.

Textbooks

1. *D. Tse and P.Viswanath, "Fundamentals of Wireless Communication", Cambridge university press, 2005*
2. *A. Goldsmith, "Wireless Communications", Cambridge University Press,2005*
3. *E.S.Gopi, "Digital signal processing for wireless communication using Matlab'', Springer, 2016*

ReferenceBooks

1. *T.S.Rappaport, "Wireless Communication Principles (2/e)", Pearson,2002.*
2. *E. Biglieri, R.Calderbank, A. Constantinides, A. Goldsmith, A.Paulraj, H.Vincent poor, "MIMO Wireless Communications", Cambridge University Press,2007.*
3. *Robert Gallager, Chapter 9: "Wireless communication", course materials for 6.450 Principles of Digital communication I,Fall 2006.MIT Open coursewarehttp://ocw.mit.edu/.*
4. *Recent literature in the related topics*

Course outcomes

Students are able to

CO1: summarize the importance of Coherence time, Coherence frequency, Doppler spread and Delay spread in time-varying wireless channel model

CO2: derive the expression for BER for various wireless channel model.

CO3: derive the expression for the computation of spectral density of various bandpass transmission and methodology to estimate from the received signal.

CO4: summarize the mathematical models related to MIMO and OFDM technology

CO5: summarize the signal processing aspects in various 5G Technology

Course Code	**:**	**ECPE33**
Course Title	**:**	**MICROWAVE INTEGRATED CIRCUIT DESIGN**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECPC16 & ECPC24**
Course Type	**:**	**PE**

Course learning Objective

- To impart knowledge on basics of microwave electron beam devices and their applications in X band frequency**.**

Course content

Design and realization of power dividers, hybrids, directional couplers etc using strip lines and micro strip lines.

Filter design; Kuroda identities. K and J inverters. Filter transformations. Realization using strip lines and micro strip lines.

Transistor amplifiers; Power gain equations. Stability considerations. Analysis .Design using MICs.

Transistor oscillator's .Active devices for microwave oscillators. Three port S parameter characterization of transistors. Oscillation and stability conditions.

Diode mixers .Mixer design. Single ended mixer. Balanced mixer .Image rejection mixer. Phase shifter design. PIN diode. Phase shifter.

Text Books

1. *I.J.Bahl & Bhartia, Microwave Solid State Circuit Design, Wiley, 1987.*
2. *G.D.Vendelin, Design of Amplifiers and Oscillators by the S Parameter Method, Wiley, 1982.*

Reference Books

1. *Stripline-like Transmission Lines for Microwave Integrated Circuits* - *Bharathi Bhat, Shiban Koul, New Age International(P) Limited, Publishers, 2007*
2. *Microwave Engineering ,David M Pozar, John Wiley & Sons,In International Student Edition*
3. *T.C.Edwards, Foundations for Microstrip Circuit Design (2/e), Wiley, 1992.*
4. *Recent literature in Microwave Integrated Circuit Design.*

Course outcomes

At the end of the course student will be able

CO1: the topics will make students design of the important and essential M.I.C components
CO2: Filter is the most needed circuit for many applications and the unit will make the student confident in filter design
CO3: All aspects and different parameters, design factors and properties will me made thorough
CO4: One will be confident to handle any oscillator design
CO5: The student will become familiar and confident in the design of Mixers, the other essential circuits.

Course Code	**:**	**ECPE34**
Course Title	**:**	**RF MEMS CIRCUIT DESIGN**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECPC16 & ECPC24**
Course Type	**:**	**PE**

Course learning Objective

- To impart knowledge on basics of MEMS and their applications in RF circuit design.

Course content

Introduction to Micromachining Processes .RF MEMS relays and switches. Switch parameters. Actuation mechanisms. Bi-stable relays and micro actuators. Dynamics of switching operation.

MEMS inductors and capacitors. Micro machined inductor .Effect of inductor layout. Modeling and design issues of planar inductor. Gap-tuning and area-tuning capacitors .Dielectric tunable capacitors.

MEMS phase shifters. Types. Limitations. Switched delay lines. Fundamentals of RF MEMS Filters. Micro machined transmission lines. Coplanar lines. Micro machined directional coupler and mixer. Micro machined antennas. Micro strip antennas –design parameters .Micromachining to improve performance. Reconfigurable antennas.

Text Book

1. *Vijay.K.Varadanetal, "RF MEMS and their Applications", Wiley*-India, 2011.

Reference Books

1. *H.J.D.Santos, "RF MEMS Circuit Design for Wireless Communications", Artech House, 2002.*
2. *G.M.Rebeiz, "RF MEMS Theory, Design, and Technology", Wiley, 2003.*
3. *Recent literature in RF MEMS Circuit Design.*

Course outcomes

At the end of the course student will be able

CO1: learn the Micromachining Processes
CO2: learn the design and applications of RF MEMS inductors and capacitors.
CO3: learn about RF MEMS Filters and RF MEMS Phase Shifters.
CO4: learn about the suitability of micro machined transmission lines for RF MEMS
CO5: learn about the Micro machined Antennas and Reconfigurable Antennas

Course Code	**:**	**ECPE35**
Course Title	**:**	**SATELLITE COMMUNICATION**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECPC18**
Course Type	**:**	**PE**

Course learning Objectives

- To introduce and to make understand the radio propagation channel for Earth station to satellite & satellite to Earth station.
- To introduce various aspects in the design of communication & multiple access systems for satellite communication.
- To introduce the concept of launchers and design of Earth station and satellite link.

Course content

Elements of orbital mechanics. Equations of motion. Tracking and orbit determination. Orbital correction/control. Satellite launch systems. Multistage rocket launchers and their performance.

Elements of communication satellite design. Spacecraft subsystems. Reliability considerations. Spacecraft integration.

Multiple access techniques. FDMA, TDMA, CDMA. Random access techniques. Satellite on-board processing.

Satellite Link Design: Performance requirement and standards. Laser Satellite Communication: Link analysis, optical satellite link transmitter, optical satellite link receiver, satellite beam acquisition, tracking & positioning, deep space optical communication link.

Earth station design. Configurations. Antenna and tracking systems. Satellite broadcasting. GPS. VSAT.

Text Books

1. *D. Roddy, "Satellite Communication (4/e)", McGraw-Hill, 2009.*
2. *T. Pratt & C. W. Bostain, "Satellite Communication", Wiley 2000.*

Reference Books

1. *Bruce R. Elbert, 'The Satellite Communication Applications' Hand Book, Artech House Bostan London, 1997.*
2. *B. N. Agrawal, "Design of Geo synchronous Spacecraft", Prentice-Hall, 1986.*
3. *A.K. Maini, V. Agrawal, "Satellite Communications", Wiley India Pvt Ltd, 1999.*
4. *Recent literature in Satellite Communication.*

Course outcomes

At the end of the course student will be able

CO1: learn the dynamics of the satellite.
CO2: learn the spacecraft and subsystems.
CO3: understand how analog and digital technologies are used for satellite communication networks.
CO4: understand the radio frequency channel from Earth station to Satellite.
CO5: study the design of Earth station and tracking of the satellites.

Course Code	**:**	**ECPE36**
Course Title	**:**	**PRINCIPLES OF RADAR**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECPC20**
Course Type	**:**	**PE**

Course learning Objective

- To expose the students to the working principles of a radar from a signal processing perspective.

Course content

Radar equation. Radar cross section. Cross section of small targets. Target scattering matrices. Area and volume targets.

Radar signals. Ambiguity function and its properties. Uncertainty principle. Pulse compression. Linear FM pulse. Pulse compression by Costas FM and binary phase coding.

Radar detection. Optimum Bayesian decision rules. Detection criteria for different target models.

Range and Doppler measurements and tracking. Range and Doppler frequency resolutions. Optimum receivers. Optimum filters for Doppler measurements. Coherent and non-coherent implementations.

Angle measurement and tracking. Angle measurement and tracking by conical scan and mono pulse. Optimum mono pulse systems.

Text Books

1. *P.Z.Peebles, Radar Principles, Wiley, 1998.*
2. *Merrill I. Skolink, Introduction to Radar Systems, (3/e), Tata MG Graw Hill,2001*

Reference Books

1. *N.Levanon, Radar Signals, Wiley, 2005.*
2. *D.Wehnar: High Resolution Radar, Artech Hous, 1987.*
3. *D.K.Barton: Radar systems Analysis, Prentice Hall, 1976.*
4. *Recent literature in Principles of Radar.*

Course outcomes
At the end of the course student will be able
CO1: Understand the principle behind radar range equation and different types of targets available.
CO2: Appreciate the different compression techniques of radar pulse signals.
CO3: Distinguish between different detection methods of radar signals.
CO4: Appreciate the building blocks for optimum receiver and Doppler measurements.
CO5: Understand the tracking and scanning methods in the mono pulse systems.

Course Code	**:**	**ECPE37**
Course Title	**:**	**LOW POWER VLSI CIRCUITS**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECPC23**
Course Type	**:**	**PE**

Course learning Objective

- To expose the students to the low voltage device modelling, low voltage, low power VLSI CMOS circuit design.

Course content

CMOS fabrication process, Shallow trench isolation. Lightly-doped drain. Buried channel. Fabrication process of BiCMOS and SOI CMOS technologies.

Modeling of CMOS devices parameters. Threshold voltage, Body effect, Short channel and Narrow channel effects, Electron temperature, and MOS capacitance.

CMOS inverters, static logic circuits of CMOS, pass transistor, BiCMOS, SOI CMOS and low power CMOS techniques.

Basic concepts of dynamic logic circuits. Various problems associated with dynamic logic circuits. Differential, BiCMOS and low voltage dynamic logic circuits.

CMOS memory circuits, Decoders, sense amplifiers, SRAM architecture. Low voltage SRAM techniques.

Text Books

1. *Jan Rabaey,"Low Power Design Essentials (Integrated Circuits and Systems)", Springer,2009*
2. *J.B.Kuo&J.H.Lou,"Low-voltage CMOS VLSI Circuits", Wiley, 1999.*

Reference Book

1. *A.Bellaowar&M.I.Elmasry,"Low power Digital VLSI Design, Circuits and Systems", Kluwer, 1996.*
2. *Recent literature in Low Power VLSI Circuits.*

Course outcomes

At the end of the course student will be able

CO1: acquire the knowledge about various CMOS fabrication process and its modeling.
CO2: infer about the second order effects of MOS transistor characteristics.
CO3: analyze and implement various CMOS static logic circuits.
CO4: learn the design of various CMOS dynamic logic circuits.
CO5: learn the different types of memory circuits and their design.

Course Code	**:**	**ECPE38**
Course Title	**:**	**ADHOC WIRELESS NETWORKS**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECPE10**
Course Type	**:**	**PE**

Course learning Objective

- To analyse the various design issues and challenges in the layered architecture of Ad hoc wireless networks

Course content

Cellular and ad hoc wireless networks, Applications of ad hoc wireless networks. Issues in ad hoc wireless networks-medium access scheme, routing, transport layer protocols, security and energy management. Ad hoc wireless internet.

Design goals of a MAC protocol, Contention based protocols; Contention based protocols with reservation mechanisms and scheduling mechanisms, MAC protocols using directional antennas.

Table driven routing protocols, On demand routing protocols, hybrid routing protocols, Hierarchical routing protocols, Power aware routing protocols, Tree based and mesh based multicast routing protocols

Network security requirements-Issues and challenges, network security attacks, key management, secure routing protocols

Energy management schemes-Battery management, transmission power management, system power management schemes. Quality of service solutions in ad hoc wireless networks.

Text books

1. *C.Siva ram murthy, B.S. Manoj, "Ad hoc wireless networks-Architectures and protocols" Pearson Education, 2005*
2. *S.Basagni, M.Conti, "Mobile ad hoc networking", Wielyinterscience2004*

References books

1. *C. E.Perkins ,"Ad hoc networking", AddisonWesley,2001*
2. *X.Cheng, X.Huang ,D.Z. DU ,"Ad hoc wireless networking", Kluwer AcademicPublishers,2004*
3. *G. Aggelou,"Mobile ad hoc networks-From wireless LANs to 4G networks", McGraw Hill publishers,2005*
4. *Recent literature in ADHOC Wireless Networks.*

Course outcomes

At the end of the course student will be able

CO1: compare the differences between cellular and ad hoc networks and the analyze the challenges at various layers and applications

CO2: summarize the protocols used at the MAC layer and scheduling mechanisms

CO3: compare and analyze types of routing protocols used for unicast and multicast routing

CO4: examine the network security solution and routing mechanism

CO5: evaluate the energy management schemes and Quality of service solution in ad hoc networks

Course Code	**:**	**ECPE39**
Course Title	**:**	**WIRELESS SENSOR NETWORKS**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECPE10**
Course Type	**:**	**PE**

Course learning Objective

- To overview the various design issues and challenges in the layered architecture of Wireless sensor networks

Course content

Motivation for a network of wireless sensor nodes-Definitions and background-challenges and constraints for wireless sensor networks-Applications. Node architecture-sensing subsystems, processing Subsystems, Communication interfaces, Prototypes.

Physical layer- Introduction, wireless channel and communication fundamentals – frequency allocation, modulation and demodulation, wave propagation effects and noise, channels models, spread spectrum communication, packet transmission and synchronization, quality of wireless channels and measures for improvement, physical layer and transceiver design consideration in wireless sensor networks, Energy usage profile, choice of modulation, Power Management

Data link layer- Fundamentals of wireless MAC protocols, Characteristics of MAC protocol in wireless sensor networks contention-based protocols, Contention free MAC protocols,Hybrid MAC protocols

Network layer-routing metrics-Flooding and gossiping, Data centric routing, proactive routing on demand routing, hierarchical routing, Location based routing, QOS based routing. Data Aggregation – Various aggregation techniques.

Case study-Target detection tracking, Habitat monitoring, Environmental disaster monitoring, Practical implementation issues, IEEE 802.15.4 low rate WPAN, Operating System Design Issues. Simulation tools.

Text Books

1. *W. Dargie, C. Poellabauer, "Fundamentals of Wireless sensor networks-Theory and Practice", John Wiley & Sons Publication2010*
2. *K. Sohraby, D.Minoli and T.Znati, "Wireless Sensor Network Technology- Protocols and Applications", John Wiley & Sons, 2007.*

Reference Books

1. *F.Zhao, L.Guibas, "Wireless Sensor Networks: an information processing approach", Elsevier publication, 2004.*
2. *C.S.Raghavendra Krishna, M.Sivalingam and Taribznati, "Wireless Sensor Networks", Springer publication, 2004.*
3. *H. Karl, A.willig, "Protocol and Architecture for Wireless Sensor Networks", John Wiley publication, Jan2006.*
4. *K.Akkaya and M.Younis, "A Survey of routing protocols in wireless sensor networks", Elsevier Adhoc Network Journal, Vol.3, no.3, pp. 325-349, 2005.*
5. *Philip Levis, "TinyOS Programming", 2006 –www.tinyos.net.*
6. *I.F. Akyildiz, W. Su, Sankarasubramaniam, E. Cayirci, "Wireless sensor networks: a survey", computer networks, Elsevier, 2002, 394 -422.*
7. *Jamal N. Al-karaki, Ahmed E. Kamal, "Routing Techniques in Wireless sensor networks: A survey", IEEE wireless communication, December 2004, 6 –28.*
8. *Recent literature in Wireless Sensor Networks.*

Course outcomes

At the end of the course student will be able

CO1: analyze the challenges and constraints of wireless sensor network and its subsystems

CO2: examine the physical layer specification, modulation and transceiver design considerations

CO3: analyze the protocols used at the MAC layer and scheduling mechanisms

CO4: compare and analyse the types of routing protocols and data aggregation techniques

CO5: identify the application areas and practical implementation issues.

Course Code	**:**	**ECPE40**
Course Title	**:**	**Nano Electronics**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**PE**

Course Objectives

- To present the state of the art in the areas of semiconductor device physics and materials technology to enable nano-electronics
- To provide and overview of nano materials and device fabrication
- To discuss the extensive materials characterization techniques

Course Content

Overview: Nano devices, Nano materials, Nano characterization. Introduction to nano-electronics, CMOS technology scaling issues, Design techniques for nanoscale transistors

MOS Electrical characterization, Non classical MOSFETs: overview and carrier transport in Nano-MOSFETs, Silicon on Insulator (SOI) MOSFET

Metal-Semiconductor contacts and Metal-Source/Drain Junction MOSFETs, Germanium and compound semiconductor Nano MOSFETs

Introduction to Nanomaterials, Quantum Mechanics and Quantum Statistics for considering Nanomaterials.

Quantum mechanics and Quantum statistics for considering nanomaterials, synthesis/fabrication of nanomaterials, chemical vapour deposition (CVD) and atomic layer deposition (ALD). Characterization techniques for nanomaterials and nano structures – FTIR, XRD, AFM, SEM, TEM, EDAX

NPTEL Link:
https://nptel.ac.in/courses/117108047

Text Books

1. *Y. Taur and T. Ning, "Fundamentals of Modern VLSI Devices", Cambridge University Press, 2nd Edition, 2013.*

Reference Books

1. *Plummer, Deal and Griffin, "Silicon VLSI Technology", 1st edition, Pearson education, 2000.*
2. *Brundle, C. R., Evans, Charles A. jr., Wilson and Shaun, "Encyclopaedia of Materials Characterization, 1992.*

Course Outcomes:

At the end of the course, student will be able to

CO1: get an insight of nano devices and nano materials
CO2: learn the nano-micro fabrication
CO3: get a foundation for the device fabrication
CO4: study vast understanding to the device electronics for integrated circuits
CO5: get an insight of nano materials and its characterization techniques.

Course Code	**:**	**ECPE41**
Course Title	**:**	**ELECTRONIC DESIGN AUTOMATION TOOLS**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**HO**

Course learning Objective

- To make the students exposed to Front end and Back end VLSI CAD tools.

Course content

OS Architecture: System settings and configuration. Introduction to UNIX commandsHandling directories, Filters and Piping, Wildcards and Regular expression, Power Filters and Files Redirection. Working on Vi editor, Basic Shell Programming, TCL Scripting language.

Algorithms in VLSI: Partitioning methods: K-L, FM, and Simulated annealing algorithms. Placement and Routing algorithms, Interconnects and delay estimation.

Synthesis and simulation using HDLs-Logic synthesis using Verilog. Memory and FSM synthesis. Performance driven synthesis, Simulation- Types of simulation. Static timing analysis. Formal verification. Switch level and transistor level simulation.

System Verilog- Introduction, Design hierarchy, Data types, Operators and language constructs. Functional coverage, Assertions, Interfaces and test bench structures.

Analog/Mixed Signal Modelling and Verification: Analog/ Mixed signal modelling using Verilog-A and Verilog-AMS. Event Driven Modelling: Real number modelling of Analog/Mixed blocks modelling using Verilog-RNM/System Verilog. Analog/Digital Boundary Issues: boundary issues coverage

Text Books

1. *M.J.S.Smith, "Application Specific Integrated Circuits", Pearson, 2008.*
2. *S.Sutherland, S. Davidmann, P. Flake, "System Verilog for Design", (2/e), Springer, 2006.*

Reference Books

1. *H.Gerez, "Algorithms for VLSI Design Automation", John Wiley, 1999*
2. *Z. Dr Mark, "Digital System Design with System Verilog ", Pearson, 2010.*
3. *Recent literature in Electronic Design Automation Tools.*

Course outcomes

At the end of the course student will be able

CO1: execute the special features of VLSI back end and front end CAD tools and UNIX shell script

CO2: explain the algorithms used for ASIC construction

CO3: design synthesizable Verilog and VHDL code.

CO4: explain the difference between Verilog and system Verilog and are able to write system Verilog code.

CO5: Model Analog and Mixed signal blocks using Verilog A and Verilog AMS

Course Code	**:**	**ECPE42**
Course Title	**:**	**Electromagnetic Interference and Compatibility**
Number of Credits	**:**	**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**Elective**

COURSE OBJECTIVE

- Electromagnetic interference (EMI) is a potential threat to the present day electronic systems. The main objective of the course is to provide insight into various sources of electromagnetic interferences and how to design an electronic product which is electromagnetically compatible with each other.

COURSE CONTENT

Introduction to EMI and EMC- Various EMC requirements and standards-Need for EMC and its importance in electronic product design - sources of EMI - few case studies on EMC.

Conducted and radiated emission -power supply line filters-common mode and differential mode current-common mode choke- switched mode power supplies. Shielding techniques- shielding effectiveness-shield behavior for electric and magnetic field -aperture-seams-conductive gaskets-conductive coatings
Grounding techniques- signal ground-single point and multi point grounding-system ground-common impedance coupling -common mode choke-Digital circuit power distribution and grounding.

Contact protection - arc and glow discharge-contact protection network for inductive loads-C, RC, RCD protection circuit- inductive kick back. RF and transient immunity-transient protection network- RFI mitigation filter-power line disturbance- ESD- human body model- ESD protection in system design.
PCB design for EMC compliance-PCB layout and stack up- multi layer PCB objectives- Return path discontinuities-mixed signal PCB layout. EMC pre compliance measurement-conducted and radiated emission test-LISN-Anechoic chamber.

Text Books:

1. *H. W. Ott, Electromagnetic Compatibility Engineering, 2nd edition, John Wiley & Sons, 2011, ISBN: 9781118210659.*
2. *C. R. Paul, Introduction to Electromagnetic Compatibility, 2nd edition, Wiley India, 2010, ISBN: 9788126528752*

Reference Book:

1. *K. L. Kaiser, Electromagnetic Compatibility Handbook, 1st edition, CRC Press, 2005. ISBN: 9780849320873*

COURSE OUTCOMES

Students are able to

CO1: Understand the various sources of Electromagnetic interference
CO2: Familiarize the fundamentals those are essential for product design with EMC compliance and various EMC standards
CO3:. would gain knowledge to understand the concept of Shielding and grounding related to product design.
CO4:. Design PCBs which are electromagnetically compatible
CO5: understand and differentiate the various EMC pre compliance measurement

Course Code	**:**	**ECPE43**
Course Title	**:**	**Computer Vision**
Number of Credits	**:**	**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**Elective**

COURSE OBJECTIVE

- The focus of this course is the understanding of algorithms and techniques used in computer vision.
- Provide pointers into the literature and exercise a project based on a literature search and one or more research papers.
- Practice software implementation of different concepts and techniques covered in the course.
- Utilize programming and scientific tools for relevant software implementation.

COURSE CONTENT

Introduction: overview of computer vision, related areas, and applications; overview of software tools; overview of course objectives.; introduction to OpenCV. Image formation and representation: imaging geometry, radiometry, digitization, cameras and projections, rigid and affine transformations, Filtering: convolution, smoothing, differencing, and scale space

Feature detection: edge detection, corner detection, line and curve detection, active contours, SIFT and HOG descriptors, shape context descriptors, Model fitting: Hough transform, line fitting, ellipse and conic sections fitting, algebraic and Euclidean distance measures.

Camera calibration: camera models; intrinsic and extrinsic parameters; radial lens distortion; direct parameter calibration; camera parameters from projection matrices; orthographic, weak perspective, affine, and perspective camera models.

Motion analysis: the motion field of rigid objects; motion parallax; optical flow, the image brightness constancy equation, affine flow; differential techniques; feature-based techniques; regularization and robust estimation; motion segmentation through EM, Motion tracking: statistical filtering; iterated estimation; observability and linear systems; the Kalman filter; the extended Kalman filter

Object recognition and shape representation: alignment, appearance-based methods, invariants, image Eigen spaces, data-based techniques.

Text Books

1. *Computer Vision: Algorithms and Applications, R. Szeliski, Springer, 2011.*
2. *Computer Vision: A Modern Approach, D. Forsyth and J. Ponce, Prentice Hall, 2nd ed., 2011.*
3. *Introductory techniques for 3D computer vision, E. Trucco and A. Verri, Prentice Hall, 1998.*

COURSE OUTCOMES

Students are able

CO1: To understand the fundamental problems of computer vision.
CO2: To learn techniques, mathematical concepts and algorithms used in computer vision to facilitate further study in this area.
CO3: To get an idea regarding the camera calibration and its importance.
CO4: To study different kinds of motion estimation methodologies and its applications.
CO5: To understand the basic concepts of object and shape recognition techniques

Course Code	**:**	**ECPE44**
Course Title	**:**	**Natural Language Processing**
Number of Credits	**:**	**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**Elective**

COURSE LEARNING OBJECTIVE

- Understand NLP tasks in syntax, semantics and pragmatics
- Implement machine learning techniques used in NLP

Introduction – Why NLP? NLP versus speech recognition- Applications-problem of ambiguity- role of machine learning in NLP- Basic neural networks for NLP

Words – Morphology and Finite State transducers-Tokenization – Computational Phonology and Pronunciation Modelling

Probabilistic models in NLP—Role of language models- Simple N-gram model – Evaluation: Perplexity and Word Error Rate. Parts of Speech Tagging- Hidden markov models–Viterbi algorithm, Maximum Entropy Markov model

Semantic analysis - Lexical semantics and word-sense disambiguation. Compositional semantics. Semantic Role Labeling and Semantic Parsing

Machine Translation- Statistical translation, word alignment, phrase-based translation, and synchronous grammars, evaluation.

Reference Books

1. Natural Language Processing, by Jacob Eisenstein, MIT Press.
2. Speech and Language Processing by Daniel Jurafsky and James H. Martin
3. Foundations of Statistical Natural Language processing by Manning C. D. and Schutze H., First Edition, MIT Press, 1999
4. Neural Network Methods for Natural Language Processing by Yoav Goldberg, Morgan & Claypool Publishers.

COURSE OUTCOMES

Students are able to
CO1: Understand NLP and the role of machine learning in NLP
CO2: Describe finite state transducer operations and pronunciation modelling in NLP
CO3: Illustrate various probabilistic models in NLP.
CO4: Study semantic analysis in NLP
CO5: Learn various machine translation approaches and the different evaluation metrics.

Course Code	**:**	**ECPE45**
Course Title	**:**	**Optimization Methods In Machine Learning**
Number of Credits	**:**	**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**Elective**

COURSE LEARNING OBJECTIVE

- The course aims to equip students with advanced techniques and methods in optimization that are tailored to large-scale statistics and machine learning problems

COURSE CONTENT

Basics of convex optimization-convex sets, convexity-preserving operations, examples of convex programs (linear programming (LP), second-order cone programming (SOCP), semidefinite programming (SDP)), convex relaxation, KKT conditions, duality

Gradient-based methods-gradient descent, subgradient, mirror descent, Frank–Wolfe method, Nesterov's accelerated gradient method, ODE interpretations, dual methods, Nesterov's smoothing, proximal gradient methods, Moreau–Yosida regularization

Operator splitting methods-augmented Lagrangian methods, alternating direction method of multipliers (ADMM), monotone operators, Douglas–Rachford splitting, primal and dual decomposition

Stochastic and nonconvex optimization-dualaveraging, Polyak–Juditsky averaging, stochastic variance reduced gradient (SVRG), Langevin dynamics, escaping saddle points, landscape of nonconvex problems, deep learning

Applications of optimization methods in Image/Video/Multimedia Processing

Textbooks:

1. *Stephen Boyd and Lieven Vandenberghe's book: Convex Optimization*
2. *Nesterov's old book: Introductory Lectures on Convex Optimization: A Basic Course*
3. *Nesterov's new book: Lectures on Convex Optimization*
4. *Neal Parikh and Stephen Boyd's monograph: Proximal Algorithms*
5. *Sebastien Bubeck's monograph: Convex Optimization: Algorithms and Complexity*

References

1. *Moritz Hardt's Berkeley EE 227C course note*
2. *Prateek Jain and Purushottam Kar's survey on nonconvex optimization*
3. *Kristin Bennett, Emilio Parrado-Hernandez. Interplay of Optimization and Machine Learning Research, Journal of Machine Learning Research, 2006.*
4. *Nati Srebro, Ambuj Tewari. Stochastic Optimization for Machine Learning, Tutorial at International Conference on Machine Learning, 2010.*

COURSE OUTCOMES

Students are able

CO1: To learn the basic concepts of convex optimization

CO2: To study gradient based optimization techniques

CO3: To understand the problem solving using operator splitting methods

CO4: To learn stochastic and non-convex optimization Techniques,

CO5: To execute applications of optimization techniques in different domains

Course Code	**:**	**ECPE46**
Course Title	**:**	**Hardware for Deep Learning**
Number of Credits	**:**	**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**Elective**

COURSE LEARNING OBJECTIVE

To get an idea about deep learning and how to implement deep learning algorithms on FPGA

COURSE CONTENT

Introduction to Deep Learning: From AI to DL, Neural Network: Perceptrons, Back Propagation, Over-fitting, Regularization. Deep Networks: Definition, Motivation, Applications, Convolution Neural Network (CNN): Basic architecture, Activation functions, Pooling, Handling vanishing gradient problem, Dropout, Weight initialization methods, Batch Normalization. Training Neural networks, Additional CNN Components, Famous CNNs, Applications, Software libraries.

Computing Convolutions: Mapping Matrix multiplication, Computational Transforms, Accelerator Architectures, Dataflow Taxonomy

Reducing the Complexity: Light weight models, reducing precision, Aggressive Quantization, pruning & Deep compression.

The Deep Learning Acceleration Landscape: parallelism in deep learning, Traditional programmable hardware, specialized deep learning hardware platforms, deep learning software stack, Specialized research ASICs.

FPGAs for Deep Learning: Overview of hardware architectures for deep learning, Effective management of FPGA memory resources, optimizing algorithms and data representation for FPGA arithmetic resources, Integrating hardware and software.

Text Books

1. *Ian Goodfellow, Yishuv Bengio and Aaron Courville, "Deep Learning." MIT Press. 2016. ISBN: 978-0262035613. Available online for free at: http://www.deeplearningbook.org*
2. *Vivienne Sze; Yu-Hsin Chen; Tien-Ju Yang; Joel S. Emer, "Efficient Processing of Deep Neural Networks" Morgan & Claypool Publishers, 1st Edition, 2020.*
3. *Tushar Krishna, Hyoukjun Kwon, Angshuman Parashar, Michael Pellauer, and Ananda Samajdar, "Data Orchestration in Deep Learning Accelerators", Morgan & Claypool Publishers, 1st Edition, 2020.*

References

1. *Piotr Antonik, "Application of FPGA to Real-Time Machine Learning", Springer, 2018.*
2. *Stanford C231n, 2017*
3. *Sze, et al. https://eyeriss.mit.edu/ ISCA Tutorial 2019*
4. *Sze, et al. "Efficient Processing of Deep Neural Networks: A Tutorial and Survey", Proceedings of the IEEE, 2017*
5. *Prof. Adam Teman https://www.eng.biu.ac.il/temanad/hardware-for-deep-learning/*
6. *https://jameswhanlon.com/*

Course outcomes

Students are able to

CO1: Understand the context of convolutional neural networks and deep learning algorithms.

CO2: Know how to use convolution in deep learning techniques.

CO3: Understand the necessity and importance of light weight models with low complexity through specialized hardware architecture

CO4: Know how to optimize hardware performance in deep neural network applications.

CO5: Discuss, suggest and evaluate specialised hardware architectures to implement deep learning algorithms in FPGA and utilise deep learning concepts in resource constrained reliable systems.

Course Code	**:**	**ECPE47**
Course Title	**:**	**Image and Video Processing**
Number of Credits	**:**	**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**Elective**

COURSE LEARNING OBJECTIVE

- The course aims to equip students with basic image and video processing techniques.

COURSE CONTENTS

Image Formation and Representation: 3D to 2D projection, photometric image formation, trichromatic colour representation, video format (SD, HD, UHD, HDR), contrast enhancement (concept of histogram, nonlinear mapping, histogram equalization)

Review of 1D Fourier transform and convolution: Concept of spatial frequency. Continuous and Discrete Space 2D Fourier transform. 2D convolution and its interpretation in frequency domain. Implementation of 2D convolution. Separable filters. Frequency response. Linear filtering (2D convolution) for noise removal, image sharpening, and edge detection. Gaussian filters, DOG and LOG filters as image.

Geometric mapping and Feature detection: Geometric mapping (affine, homography), Feature based camera motion estimation (RANSAC). Image warping. Image registration. Panoramic view stitching, Feature detection (Harris corner, scale space, SIFT), feature descriptors (SIFT). Bag of Visual Word representation for image classification.

Motion estimation: optical flow equation, optical flow estimation (Lucas-Kanade method, KLT tracker); block matching, multi-resolution estimation. Deformable registration (medical applications), Moving object detection (background/foreground separation): Robust PCA (low rank + sparse decomposition). Global camera motion estimation from optical flows. Video stabilization. Video scene change detection.

Video Coding: block-based motion compensated prediction and interpolation, adaptive spatial prediction, block-based hybrid video coding, rate-distortion optimized mode selection, rate control, Group of pictures (GoP) structure, tradeoff between coding efficiency, delay, and complexity, depth from disparity, disparity estimation, view synthesis. Multiview video compression. Depth camera (Kinect). 360 video camera and view stitching.

Text Book/References:

1. *Richard Szeliski, Computer Vision: Algorithms and Applications. (Available online:"Link") (Cover most of the material, except sparsity-based image processing and image and video coding)*
2. *(Optional) Y. Wang, J. Ostermann, and Y.Q.Zhang, Video Processing and Communications. Prentice Hall, 2002. "Link" (Reference for image and video coding, motion estimation, and stereo)*
3. *(Optional) R. C. Gonzalez and R. E. Woods, Digital Image Processing, Prentice Hall, (3rd Edition) 2008. ISBN number 9780131687288. "Link" (Good reference for basic image processing, wavelet transforms and image coding).*

COURSE OUTCOMES

Students are able to

CO1: Understand the concept of image formation and representation

CO2: Know the need of transformation and convolution

CO3: Understand the necessity and importance of feature detection and geometric mapping

CO4: Know how to do motion estimation in video

CO5: To understand the basic ideas of video coding

Course Code	**:**	**ECPE48**
Course Title	**:**	**Automated Test Engineering for Electronics**
Number of Credits	**:**	**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**Elective**

COURSE CONTENT

Printed Circuit Boards (PCBs) – types of PCB – multilayer PCBs – Plated though Hole Technology (PTH) - Surface Mount Technology (SMT) – Ball Grid Array (BGA) Technology. Bare PCB electrical test concepts, Loaded PCB Visual inspection, Automated Optical inspection systems, X-Ray inspection systems- Measuring Passive components – 2 wire, 3 wire, 4 wire and 6 wire measurement concepts, Guarding techniques, Shorts location, Most common manufacturing defects, Automated Manufacturing defect analyzers, Nodal Impedance / analog signature analysis. Flying probe testers.

Concepts of PCB Trouble-shooting, Symptom recognition, Bracketing technique, Failure types and fault causes, Manual Trouble shooting, Use of DMM, Oscilloscope, Signal Generators, Logic Probes, Logic Pulsers, Logic Analyzers, Automated Test Techniques – CPU Emulation technique, ROM Emulation, In-Circuit Comparators, In- Circuit Emulators, Functional Testing of Digital ICs, Library models, Concepts of In-circuit Testing, - Back Driving technique – international defence standards - Auto Compensation, In-Circuit Test of Open collector / Emitter Devices, Tri-State, Bi-Directional Devices, Concepts of Digital Guarding, Analog and Mixed Signal ICs Test, advantages and limitations of in-circuit testing, AC – DC Parametric testing, –Advanced test techniques- Boundary Scan Test , Learn and compare technique – digital signatures, Bus Cycle Signature Test , Analog signatures.

ATE system components, Main Test Vector processor, Digital Subsystem, Pin Electronics, Programmable drive and threshold levels, RAM behind each pin, Controlling slew rate, Skew between channels, Data formats, Digital and analog simulation, Test Vector Generation, Fault simulation, Fault coverage, Test Languages, Verilog, VHDL, Automatic compare, Analog Sub system, Digital and analog matrix switch circuits, digital and analog highways, Integration of JTAG, Boundary Scan Test, BSDL, External Instrumentation, Functional and Timing tests.

Concepts of Test Program (T.P) Generation. Commercially available off the shelf Test Equipment's (COTS)

Board Functional Test (BFT) techniques – Go-No-go Test – Diagnostic Test, Reliability Test, Thermal Shock Test, Full functional Edge to edge test, Cluster Test – Guided Probe Backtracking Technique – Simulators – Online and Offline Simulation - Fault Simulation– Comprehensiveness of Board program – Fault Dictionary– Analysis – BS and Non-BS device testing–- Sample board programming and testing – BS interconnect and simulating faults - External Instrumentation used for board testing – PXI Instrumentation – Integration of PXI instruments for testing

Design for testability (DFT) and Design for manufacturability (DFM) - Basics of ATPG, – Fault Models – – Design considerations for edge functional test, Design considerations for Bus Cycle Signature Test, Design considerations for Boundary Scan Test, Built-in Self-Test, Modular Design– ATE for test - DFM - Manufacturing phases in industry oriented Production process – strategies – new strategy - benefits of new strategies

Reference Books:

1. *Test Engineering for Electronic Hardware – S R Sabapathi, Qmax Test Equipments P Ltd., 2011*
2. *Practical Electronic Fault Finding and Troubleshooting - Robin Pain Newnes, Reed Educational and professional publishing Ltd., 1996*
3. *The Fundamentals of Digital Semiconductor Testing, Floyd, Pearson Education India, Sep-2005*
4. *Building a Successful Board Test Strategy-Stephen F Scheiber-Butterworth Heinemann*

COURSE OUTCOMES

Students are able to

CO1: Understand PCB and various manufacturing techniques.
CO2: Understand common PCB failure detection techniques.
CO3: Understand the various ATE system components.
CO4: Know different board functional test techniques.
CO5: Understand the basic considerations for design manufacturability and testability.

Course Code	**:**	**ECPE49**
Course Title	**:**	**Foundations of Artificial Intelligence**
Number of Credits	**:**	**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**Elective**

COURSE LEARNING OBJECTIVE

- Approaches to produce "intelligent" systems, Knowledge representation (both symbolic and neural network), search and machine learning.
- To learn the principles and fundamentals of designing AI programs.

Introduction to AI-Problem Solving as State Space Search, Uniformed Search, Heuristic Search, Informed Search, Constraint Satisfaction Problems, Searching AND/OR Graphs.

Knowledge representation and Reasoning-Introduction to Knowledge Representation, Propositional Logic, First Order Logic –I, First Order Logic –II, Inference in First Order Logic-I, Inference in First Order Logic – II, Answer Extraction, Procedural Control of Reasoning, Reasoning under Uncertainty, Bayesian Network, Decision Network.

Planning and decision Making-Introduction to Planning, Plan Space Planning, Planning Graph and Graph Plan, Practical Planning and Acting, Sequential Decision Problems, Making Complex Decisions.

Machine Learning-Introduction to Machine Learning, Learning Decision Trees, Linear Regression, Support Vector Machines, Unsupervised Learning, Reinforcement Learning,

Introduction to deep learning, neural network learning

<u>Text Books</u>

1. Patrick Henry Winston, Artificial Intelligence, Third Edition, Addison-Wesley Publishing Company, 2004.

2. Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach, 3rd Edition, PHI 2009.

<u>References</u>

1. Nils J Nilsson, Principles of Artificial Intelligence, Illustrated Reprint Edition, Springer Heidelberg, 2014.

2. Nils J. Nilsson, Quest for Artificial Intelligence, First Edition, Cambridge University Press, 2010.

COURSE OUTCOMES

Students are able

CO1: To learn the concepts of artificial intelligence

CO2: To study problem solving techniques

CO3: To understand the representation of knowledge and reasoning mechanism

CO4: To learn to panning and decision making

CO5: To study network models used for learning

Course Code	**:**	**ECPE50**
Course Title	**:**	**Photonic Integrated Circuits**
Number of Credits	**:**	**3**
Course Type	**:**	**Elective**

COURSE LEARNING OBJECTIVES

- The photonic integrated circuits course will introduce the basics of integrated optical waveguides used in optical communication applications.
- To introduce the concept reconfigurable architecture design in Photonic circuits
- To understand and realize Application-Specific Photonic Integrated Circuits and devices for Classical Applications
- This course also covers materials and fabrication technology for optical integrated circuits.

COURSE CONTENT

Brief history of optical communication, Advantages of integrated optics configuration, Guided TE and TM Modes of Symmetric and anti-symmetric planar waveguides: Step-index and graded-index waveguides. Strip and channel waveguides, Beam propagation method.

Directional couplers, Applications as power splitters, Y-junction, optical switch; modulators, filters, A/D converters, Mode splitters, Mach-Zehnder interferometer based devices.

Acousto-optic waveguide devices. Arrayed waveguide devices, Nano-photonic-devices: Metal/dielectric plasmonic waveguides, Surface Plasmon modes, applications in waveguide polarizers.

Materials. Glass, lithium niobate, silicon, compound semiconductors. Fabrication of integrated optical waveguides and devices. Lithography, deposition.

Waveguide characterisation, prism coupling, grating and tapered couplers, Nonlinear effects in integrated optical waveguides, Types and Applications.

Text Books

1. *H Nishihara, M Haruna and T Suhara, Optical Integrated Circuits; McGraw-Hill Book Company, New York, 1989.*
2. *C. R. Pollock and M Lipson, Integrated photonics, Kluwer Pub, 2003.*
3. *José Capmany and Daniel Pérez, Photonic Integrated Circuits, Oxford Univversity Press, 2020*

Reference Books

1. *A Ghatak and K Thyagarajan, Optical Electronics, Cambridge University Press, 1989.*
2. *T. Tamir, Guided wave opto-electronics, Springer Verilag, 1990*
3. *K. Okamota, Fundamentals of Optical waveguides, Academic Press, 2006.*
4. *T. Tamir, Integrated Optics, Springer Verlag, New York, 1982.*
5. *Recent journals and conference proceedings.*

Course outcomes

At the end of the course student will be able

CO1: Summarize the fundamental concept of optical waveguides.

CO2: Construct the different types of optical waveguides.

CO3: Construct the couplers, modulators and devices for communication applications

CO4: Summarize fabrication technologies for design of optical waveguides

CO5: Describe the various nonlinear effects in integrated optical waveguides.

Course Code	**:**	**ECPE51**
Course Title	**:**	**Microwave Circuits**
Number of Credits	**:**	**3**
Course Type	**:**	**Elective**

COURSE OBJECTIVE

- To make the students familiarize with ABCD parameters, S parameters, Applications of planar transmission lines in the practical microwave circuits, Design and layout of all Microwave Integrated Circuit Design components and then systems.

COURSE CONTENT

Introduction and application of microwave circuits - Two-port network characterization. ABCD parameters, Conversion of S matrix in terms of ABCD matrix. Scattering matrix representation of microwave components. Review of Smith chart and its application- Impedance matching using Lumped and Distributed approach.

Microwave Passive circuit design: Characteristics, properties, design parameters and applications- Design and realization of MIC Power dividers. 3 dB hybrid design. Directional Coupler design- Hybrid ring design.

Microwave filter design- Filter design by insertion loss method –Richards and Kuroda transformation. K inverter, J inverter. Resonator filters. Realization using microstrip lines and strip lines.

Microwave amplifier design- Power gain equations -Stability considerations. Maximum gain design, Design for specific gain -Low Noise Amplifier Design. High power design.

Microwave oscillator design. One – port and two – port negative resistance oscillators and oscillator design

Text Books:

1. *Reinhold Ludwig, RF circuit design, 2nd edition, Prentice Hall 2014, ISBN: 978-0131471375*
2. *David. M. Pozar, Microwave engineering, 4th edition, John Wiley, 2011, ISBN: 978-0470631553.*
3. *Devendra K. Misra, "Radio-Frequency and microwave communication circuits analysis and design", 2nd edition, University of Wisconsin-Mulwaukee, A John Wiley & Sons Publication*

Reference Books:

1. *B. Bhat, S. K Koul, "Stripline like transmission lines for Microwave Integrated Circuits", New Age International Pvt. Ltd Publishers, 2007.*
2. *I.J.Bahl & P.Bhartia, "Microwave Solid state Circuit Design (2/e)", Wiley, 2003.*
3. *Matthew M. Radmanesh, Radio Frequency and Microwave Electronics Illustrated, Prentice Hall, 2012*
4. *S.Y.Liao, "Microwave Circuit Analysis and Amplifier Design", Prentice-Hall, 1986.*
5. *G. Mathaei, L young, E.M.T. Jones, "Microwave filters, Impedance-Matching networks and Coupling structures", Artech House Books.*

COURSE OUTCOMES

Students are able to

CO1: Understand the basics of Scattering matrix and two port characterization and importance of matching circuits.

CO2: Analyze the working principles of couplers, power dividers etc. and their design.

CO3: Design the different types of MIC filters and their implementation.

CO4: Understand the complexities of microwave amplifier design and its stability features.

CO5: Analyze and appreciate the design principles of microwave oscillators.

Course Code	**:**	**ECPE52**
Course Title	**:**	**Introduction to Machine Learning**
Number of Credits	**:**	**3**
Course Type	**:**	**Elective**

COURSE CONTENT:

Statistical Decision Theory - Regression, Classification, Bias Variance, Linear Regression, Multivariate Regression, Subset Selection, Shrinkage Methods, Principal Component Regression, Partial Least squares

Linear Classification, Logistic Regression, Linear Discriminant Analysis, Perceptron, Support Vector Machines, Neural Networks - Introduction, Early Models, Perceptron Learning, Backpropagation, Initialization, Training & Validation, Parameter Estimation - MLE, MAP, Bayesian Estimation

Decision Trees, Regression Trees, Stopping Criterion & Pruning loss functions, Categorical Attributes, Multiway Splits, Missing Values, Decision Trees - Instability Evaluation Measures, Bootstrapping & Cross Validation, Class Evaluation Measures, ROC curve, MDL, Ensemble Methods - Bagging, Committee Machines and Stacking, Boosting

Gradient Boosting, Random Forests, Multi-class Classification, Naive Bayes, Bayesian Networks, Undirected Graphical Models, HMM, Variable Elimination, Belief Propagation, Partitional Clustering, Hierarchical Clustering, Birch Algorithm, CURE Algorithm, Density-based Clustering,

Gaussian Mixture Models, Expectation Maximization, Learning Theory, Introduction to Reinforcement Learning

References

1. *The Elements of Statistical Learning, by Trevor Hastie, Robert Tibshirani, Jerome H. Friedman*
2. *Pattern Recognition and Machine Learning, by Christopher Bishop*
3. *Machine Learning: A Bayesian and Optimization Perspective by Sergios Theodoridis*
4. *C229 Machine learning lecture notes, Stanford university by Andrew NG*

COURSE OUTCOMES

1. Understand various regression and classification algorithms
2. Develop machine learning algorithms for practical applications
3. Basic Neural networks and back propagation.
4. Develop an intuition about the bias variance trade-off
5. Introduction to reinforcement learning and Unsupervised learning

Course Code	**:**	**ECPE53**
Course Title	**:**	**Deep Learning**
Number of Credits	**:**	**3**
Course Type	**:**	**Elective**

COURSE CONTENTS

Machine learning, Introduction to Deep learning, McCulloch Pitts Neuron, Thresholding Logic, Perceptrons, Perceptron Learning Algorithm and Convergence, Multilayer Perceptrons (MLPs), Representation Power of MLPs, Sigmoid Neurons, Gradient Descent, Feedforward Neural Networks, Representation Power of Feedforward Neural Networks,

Gradient Descent (GD), Momentum Based GD, Nesterov Accelerated GD, Stochastic GD, AdaGrad, RMSProp, Adam, Regularization, Bias Variance Tradeoff, L2 regularization, Early stopping, Dataset augmentation, Parameter sharing and tying, Injecting noise at input, Ensemble methods, Dropout.

Greedy Layer wise Pre-training, activation functions, weight initialization methods, Batch Normalization, Convolutional Neural Networks, LeNet, AlexNet, ZF-Net, VGGNet, GoogLeNet, ResNet

Recurrent Neural Networks, Backpropagation Through Time (BPTT), Vanishing and Exploding Gradients, Truncated BPTT, Gated Recurrent Units (GRUs), Long Short-Term Memory (LSTM) Cells, Solving the vanishing gradient problem with LSTMs

Encoder Decoder Models, Attention Mechanism, Attention over images, Hierarchical Attention, Multi-headed Self Attention, Cross Attention, Autoencoders

Books and References

1. *Ian Goodfellow and Yoshua Bengio and Aaron Courville. Deep Learning. An MIT Press book. 2016.*
2. *Charu C. Aggarwal. Neural Networks and Deep Learning: A Textbook. Springer. 2019.*
3. *Dive into Deep Learning*

COURSE OUTCOMES

1. Study the basic feedforward neural network and backpropagation algorithm
2. Understanding the various regularization approached used in deep learning
3. Understand the Convolutional neural networks
4. Understand the recurrent neural networks
5. Develop an intuition about attention and encoder decoder architecture

Course Code	**:**	**ECOE10**
Course Title	**:**	**MICROWAVE INTEGRATED CIRCUITS**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**OE**

Course learning Objective

- To impart knowledge on basics of microwave electron beam devices and their applications in X band frequency**.**

Course content

Design and realization of power dividers, hybrids, directional couplers etc using strip lines and micro strip lines.

Filter design; Kuroda identities. K and J inverters. Filter transformations. Realization using strip lines and micro strip lines.

Transistor amplifiers; Power gain equations. Stability considerations. Analysis. Design using MICs.

Transistor oscillators. Active devices for microwave oscillators. Three port S parameter characterization of transistors. Oscillation and stability conditions.

Diode mixers. Mixer design. Single ended mixer. Balanced mixer. Image rejection mixer. Phase shifter design. PIN diode. Phase shifter.

Text Books

1. *I.J.Bahl & Bhartia, Microwave Solid State Circuit Design, Wiley, 1987.*
2. *G.D.Vendelin, Design of Amplifiers and Oscillators by the S Parameter Method, Wiley, 1982.*

Reference Books

1. *Stripline-like Transmission Lines for Microwave Integrated Circuits* - *Bharathi Bhat, Shiban Koul, New Age International(P) Limited, Publishers, 2007*
2. *Microwave Engineering, David M Pozar, John Wiley & Sons, Inc International Student Edition.*
3. *T.C.Edwards, Foundations for Microstrip Circuit Design (2/e), Wiley, 1992.*
4. *Recent literature in Microwave Integrated Circuit Design.*

Course outcomes

At the end of the course student will be able

CO1: the topics will make students design of the important and essential M.I.C components

CO2: Filter is the most needed circuit for many applications and the unit will make the student confident in filter design

CO3: All aspects and different parameters, design factors and properties will me made thorough

CO4: One will be confident to handle any oscillator design

CO5: The student will become familiar and confident in the design of Mixers, the other essential circuits.

Course Code	**:**	**ECOE11**
Course Title	**:**	**RF MEMS CIRCUIT**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**OE**

Course learning Objective

- To impart knowledge on basics of MEMS and their applications in RF circuit design.

Course content

Introduction to Micromachining Processes. RF MEMS relays and switches. Switch parameters. Actuation mechanisms. Bi-stable relays and micro actuators. Dynamics of switching operation.

MEMS inductors and capacitors. Micro machined inductor. Effect of inductor layout. Modeling and design issues of planar inductor. Gap-tuning and area-tuning capacitors. Dielectric tunable capacitors.

MEMS phase shifters. Types. Limitations. Switched delay lines. Fundamentals of RF MEMS Filters. Micro machined transmission lines. Coplanar lines. Micro machined directional coupler and mixer. Micro machined antennas. Micro strip antennas –design parameters. Micromachining to improve performance. Re configurable antennas.

Text Book

1. *Vijay.K.Varadanetal, "RF MEMS and their Applications", Wiley-India, 2011.*

Reference Books

1. *H.J.D.Santos, "RF MEMS Circuit Design for Wireless Communications", Artech House, 2002.*
2. *G.M.Rebeiz, "RF MEMS Theory, Design, and Technology", Wiley, 2003.*
3. *Recent literature in RF MEMS Circuit Design.*

Course outcomes

At the end of the course student will be able

CO1: learn the Micro machining Processes
CO2: learn the design and applications of RF MEMS inductors and capacitors.
CO3: learn about RF MEMS Filters and RF MEMS Phase Shifters.
CO4: learn about the suitability of micro machined transmission lines for RF MEMS
CO5: learn about the Micro machined Antennas and Reconfigurable Antennas

Course Code	**:**	**ECOE12**
Course Title	**:**	**HIGH SPEED SYSTEM DESIGN**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**OE**

Course Learning Objective

- To expose the students to all aspects of electronic packaging including electrical, thermal, mechanical and reliability issues.

Course Content

Functions of an Electronic Package, Packaging Hierarchy, IC packaging: MEMS packaging, consumer electronics packaging, medical electronics packaging, Trends, Challenges, Driving Forces on Packaging Technology, Materials for Microelectronic packaging, Packaging Material Properties, Ceramics, Polymers, and Metals in Packaging, Material for high density interconnect substrates

Overview of Transmission line theory, Clock Distribution, Noise Sources, power Distribution, signal distribution, EMI; crosstalk and nonideal effects; signal integrity: impact of packages, vias, traces, connectors; non-ideal return current paths, high frequency power delivery, simultaneous switching noise; system-level timing analysis and budgeting; methodologies for design of high speed buses; radiated emissions and minimizing system noise.

Electrical Anatomy of Systems Packaging, Signal Distribution, Power Distribution, Electromagnetic Interference, Design Process Electrical Design: Interconnect Capacitance, Resistance and Inductance fundamentals; Transmission Lines , Clock Distribution, Noise Sources, power Distribution, signal distribution, EMI, Digital and RF Issues. Processing Technologies, Thin Film deposition, Patterning, Metal to metal joining.

IC Assembly – Purpose, Requirements, Technologies, Wire bonding, Tape Automated Bonding, Flip Chip, Wafer Level Packaging , reliability, wafer level burn – in and test.Single chip packaging: functions, types, materials processes, properties, characteristics, trends. Multi-chippackaging : types, design, comparison, trends. Passives: discrete, integrated, and embedded –encapsulation and sealing: fundamentals, requirements, materials, processes

Printed Circuit Board: Anatomy, CAD tools for PCB design, Standard fabrication, Microvia Boards. Board Assembly: Surface Mount Technology, Through Hole Technology, Process Control and Design challenges. Thermal Management, Heat transfer fundamentals, Thermal conductivity and resistance, Conduction, convection and radiation – Cooling requirements.

Reliability, Basic concepts, Environmental interactions. Thermal mismatch and fatigue – failures – thermo-mechanically induced – electrically induced – chemically induced. Electrical Testing: System level electrical testing, Interconnection tests, Active Circuit Testing, Design for Testability.

Text Book

1.*Tummala, Rao R., Fundamentals of Microsystems Packaging, McGraw Hill, 2001*
2.*HowardJohnson , Martin Graham, High Speed Digital Design: A Handbook of Black Magic, Prentice Hall, 1993*

Reference Books

1.*Blackwell (Ed), The electronic packaging handbook, CRC Press, 2000.*
2.*Tummala, Rao R, Microelectronics packaging handbook, McGraw Hill, 2008.*
3. *Bosshart, Printed Circuit Boards Design and Technology,TataMcGraw Hill, 1988.*
4. *R.G. Kaduskar and V.B.Baru, Electronic Product design, Wiley India, 2011*
5. *R.S.Khandpur, Printed Circuit Board, Tata McGraw Hill, 2005*
6. *Recent literature in Electronic Packaging.*

Course outcomes

At the end of the course student will be able

CO1: Design of PCBs which minimize the EMI and operate at higher frequency.

CO2: Enable design of packages which can withstand higher temperature, vibrations and shock.

Course Code	**:**	**ECOE13**
Course Title	**:**	**DIGITAL SPEECH PROCESSING**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECPC15**
Course Type	**:**	**OE**

Course learning Objective

- The purpose of this course is to explain how DSP techniques could be used for solving problems in speech communication.

Course content

Speech production model-1D sound waves-functional block of the Vocal tract model –Linear predictive co- efficients (LPC) -Auto-correlation method-Levinson-Durbin algorithm-Auto-co-variance method-Lattice structure-Computation of Lattice co-efficient from LPC-Phonetic Representation of speech-Perception of Loudness - Critical bands – Pitch perception – Auditory masking.

Feature extraction of the speech signal: Endpoint detection-Dynamic time warping- Pitch frequency estimation: Autocorrelation approach- Homomorphic approach-Formant frequency estimation using vocal tract model and Homomorphic approach-Linear predictive co-efficient -Poles of the vocal tract-Reflection co-efficient-Log Area ratio.

Cepstrum- Line spectral frequencies- Functional blocks of the ear- Mel frequency cepstral co-efficient- Spectrogram-Time resolution versus frequency resolution-Discrete wavelet transformation.

Pattern recognition for speech detection: Back-propagation Neural Network-Support Vector Machine-Hidden Markov Model (HMM)-Gaussian Mixture Model(GMM) -Unsupervised Learning system: K-Means and Fuzzy K-means clustering - Kohonen self-organizing map-Dimensionality reduction techniques: Principle component analysis (PCA), Linear discriminate analysis (LDA), Kernel-LDA (KLDA), Independent component analysis(ICA).

Non-uniform quantization for Gaussian distributed data- Adaptive quantization-Differential pulse code modulation- Code Exited Linear prediction (CELP)-Quality assessment of the compressed speech signal Text to Speech (TTS) analysis –Evolution of speech synthesis systems-Unit selection methods - TTS Applications.

Text Books

1. *L.R.Rabiner and R.W.Schafer, "Introduction to Digital speech processing", now publishers USA,2007*
2. *E.S.Gopi, "Digital speech processing using matlab", Springer, 2014.*

Reference Books

1. *L.R.Rabiner and R.W.Schafer, "Digital processing of speech signals", PrenticeHall,1978*
2. *T.F.Quatieri,"Discrete-time Speech Signal Processing", Prentice-Hall, PTR,2001*
3. *L.Hanzaetal, "Voice Compression and Communications", Wiley/ IEEE, 2001.*
4. *Recent literature in Digital speech processing.*

Course outcomes

At the end of the course student will be able

CO1: illustrate how the speech production is modeled

CO2: summarize the various techniques involved in collecting the features from the speech signal in both time and frequency domain

CO3: summarize the functional blocks of the ear

CO4: compare the various pattern recognition techniques involved in speech and speaker detection

CO5: summarize the various speech compression techniques

Course Code	**:**	**ECOE14**
Course Title	**:**	**DIGITAL IMAGE PROCESSING**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**OE**

Course learning Objective

- To treat the 2D systems as an extension of 1D system design and discuss techniques specific to 2D systems.

Course content

Linearity and space-invariance. PSF, Discrete images and image transforms, 2-D sampling and reconstruction, Image quantization, 2-D transforms and properties.

Image enhancement-Histogram modeling, equalization and modification. Image smoothing, Spatial filtering, Generalized cepstrum and homomorphic filtering.

Image restoration-image observation models. Inverse and Wiener filtering. Filtering using image transforms. Constrained least-squares restoration.

Image analysis-applications, Spatial and transform features. Edge detection, boundary extraction, Moments as features.

Morphological operations and transforms. Texture. Scene matching and detection. Segmentation and classification.

Text Books

1. *A.K. Jain, "Fundamentals of Digital Image Processing", PHI, 1995.*
2. *R.C.Gonzalez & R.E. Woods," Digital Image Processing", (2/e), Pearson, 2002.*

Reference Books

1. *J.C. Russ, "The Image Processing Handbook", (5/e), CRC, 2006.*
2. *E.S.Gopi, "Digital Image processing using Matlab", Scitech publications, 2006.*
3. *Recent literature in Digital Image processing.*

Course outcomes

At the end of the course student will be able

CO1: analyze the need for image transforms, types and their properties.
CO2: become skilled at different techniques employed for the enhancement of images both in spatial and frequency domain.
CO3: explore causes for image degradation and to teach various restoration techniques.
CO4: evaluate the image compression techniques in spatial and frequency domain.
CO5: gain knowledge of feature extraction techniques for image analysis and recognition.

Course Code	**:**	**ECOE15**
Course Title	**:**	**PATTERN RECOGNITION**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**OE**

Course learning Objective

- The subject aims to make the students to understand the mathematical approach for pattern recognition.

Course content

Polynomial curve fitting – The curse of dimensionality - Decision theory - Information theory - The beta distribution - Dirichlet distribution-Gaussian distribution-The exponent family: Maximum likelihood and sufficient statistics -Non-parametric method: kernel-density estimators - Nearest neighbourmethods.

Linear models for regression and classification: Linear basis function models for regression - Bias variance decomposition-Bayesian linear regression-Discriminant functions - Fisher's linear discriminant analysis (LDA) - Principal Component Analysis (PCA) - Probabilistic generative model - Probabilistic discriminative model.

Kernel methods: Dual representations-Constructing kernels-Radial basis function networks-Gaussian process-Maximum margin classifier (Support Vector Machine) –Relevance Vector Machines-Kernel-PCA, Kernel-LDA.

Mixture models: K-means clustering - Mixtures of Gaussian - Expectation-Maximization algorithm-Sequential models: Markov model, Hidden-Markov Model (HMM) - Linear Dynamical Systems(LDS).

Neural networks: Feed- forward Network functions-Network training - Error Back propagation - The Hessian Matrix - Regularization in Neural Network - Mixture density networks – Bayesian Neural Networks

TextBooks

1. *C.M.Bishop,"Pattern recognition and machinelearning",Springer,2006*
2. E.S.Gopi, "Pattern recognition and Computational intelligence using matlab, Transactions on computational science and computational intelligence, Springer, 2019

ReferenceBooks

1. Sergious Thedorodis ,Konstantinos Koutroumbas, Pattern recognition, Elsevier, Fourth edition,2009
2. *Richard O.Duda, Peter.E.Hart, David G.Stork, "Pattern classification", Wiley, Second edition,2016*
3. *Recent literature in the related topics*

COURSEOUTCOMES

Students are ableto

CO1: summarize the various techniques involved in patternrecognition
CO2: identify the suitable pattern recognition techniques for the particular applications.
CO3: categorize the various pattern recognition techniques into supervised andunsupervised.
CO4: summarize the mixture models based pattern recognitiontechniques
CO5: summarize the artificial neural network based pattern recognitiontechniques

Course Code	**:**	**ECOE16**
Course Title	**:**	**COMPUTER ARCHITECTURE AND ORGANIZATION**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**OE**

Course learning Objectives

- To understand how computers are constructed out of a set of functional units and how the functional units operate, interact, and communicate.
- To make the students to understand the concept of interfacing memory and various I/O devices to a computer system using a suitable bus system.

Course content

Introduction: Function and structure of a computer, Functional components of a Computer, Interconnection of components, Performance of a computer.

Representation of Instructions: Machine instructions, Memory locations & Addresses, Operands, Addressing modes, Instruction formats, Instruction sets, Instruction set architectures - CISC and RISC architectures, Super scalar Architectures, Fixed point and floating point operations.

Basic Processing Unit: Fundamental concepts, ALU, Control unit, Multiple bus organization, Hardwired control, Micro programmed control, Pipelining, Data hazards, Instruction hazards, Influence on instruction sets, Data path and control considerations, Performance considerations.

Memory organization: Basic concepts, Semiconductor RAM memories, ROM, Speed - Size and cost, Memory Interfacing circuits, Cache memory, Improving cache performance, Memory management unit, Shared/Distributed Memory, Cache coherency in multiprocessor, Segmentation, Paging, Concept of virtual memory, Address translation, Secondary storage devices.

I/O Organization: Accessing I/O devices, Input/output programming, Interrupts, Exception Handling, DMA, Buses, I/O interfaces- Serial port, Parallel port, PCI bus, SCSI bus, USB bus, Firewall and Infini band, I/O peripherals.

Text Books

1. *C.Hamacher Z. Vranesic and S. Zaky, "Computer Organization", McGraw-Hill, 2002.*
2. *W. Stallings, "Computer Organization and Architecture - Designing for Performance", Prentice Hall of India, 2002.*

References Books

1. *B,Parhami, "Computer Architecture, From Microprocessors to Supercomputers," Oxford University Press, Reprint2014.*
2. *D. A. Patterson and J. L. Hennessy, "Computer Organization and Design,*
3. *Morgan Kaufmann,"The Hardware/Software Interface", 1998.*
4. *J .P. Hayes, "Computer Architecture and Organization", McGraw-Hill, 1998.*
5. *Recent literature in Computer Architecture and Organization.*

Course outcomes

At the end of the course student will be able

CO1: apply the basic knowledge of digital concept to the functional components of a Computer System.
CO2: analyze the addressing mode concepts and design the instruction set Architecture.
CO3: identify the functions of various processing units within the CPU of a Computer System.
CO4: analyze the function of the memory management unit and create suitable memory interface to the CPU.
CO5: recognize the need for recent Bus standards and I/O devices.

Course Code	**:**	**ECOE17**
Course Title	**:**	**OPERATING SYSTEMS**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**OE**

Course learning Objective

- To expose the principles and practice of operating system design and to illustrate the current design practices using DOS and UNIX operating systems.

Course content

Types of operating systems, Different views of the operating system, Principles of Design and Implementation. The process and threads. System programmer's view of processes, Operating system's views of processes, Operating system services for process management. Process scheduling, Schedulers, Scheduling algorithms. Overview of Linux operating system.

Interprocess synchronization, Mutual exclusion algorithms, Hardware support, Semaphores, Concurrent programming using semaphores.

Conditional critical regions, Monitors, Inter process communication: Messages, Pipes. Deadlocks: Characterization. Prevention. Avoidance. Detection and recovery. Combined approach to deadlock handling.

Contiguous allocation. Static and dynamic partitioned memory allocation. Segmentation. Non- contiguous allocation. Paging, Hardware support, Virtual Memory.

Need for files. File abstraction. File naming. File system organization. File system optimization. Reliability. Security and protection. I/O management and disk scheduling. Recent trends and developments.

Text Books

1. *Gary: Operating Systems- A modern Perspective, (2/e), Addison Wesley, 2000.*
2. *M.Milenkovic: Operating systems, Concepts and Design, McGraw Hill, 1992.*

Reference Books

1. *C. Crowley: Operating Systems, Irwin, 1997.*
2. *J.l. Peterson & A.S. Chatz: Operating System Concepts, Addison Wesley, 1985.*
3. *W. Stallings: Operating Systems, (2/e), Prentice Hall, 1995.*
4. *Mattuck,A., Introduction to Analysis,Prentice-Hall,1998.*
5. *Recent literature in Operating Systems.*

Course outcomes

At the end of the course student will be able

CO1:.Understand the different types of Operating systems and scheduling algorithms.
CO2: Understand the synchronization algorithms and semaphores.
CO3: Appreciate the inter process communication and deadlock handling.
CO4: Critically evaluate the different memory allocation techniques.
CO5: Appreciate the importance of file system organization, I/O management and disk scheduling.

Course Code	**:**	**ECOE18**
Course Title	**:**	**WIRELESS SENSOR NETWORKS**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECPE10**
Course Type	**:**	**OE**

Course learning Objective

- To overview the various design issues and challenges in the layered architecture of Wireless sensor networks

Course content

Motivation for a network of wireless sensor nodes-Definitions and background-challenges and constraints for wireless sensor networks-Applications. Node architecture-sensing subsystems, processing Subsystems, Communication interfaces, Prototypes.

Physical layer- Introduction, wireless channel and communication fundamentals – frequency allocation, modulation and demodulation, wave propagation effects and noise, channels models, spread spectrum communication, packet transmission and synchronization, quality of wireless channels and measures for improvement, physical layer and transceiver design consideration in wireless sensor networks, Energy usage profile, choice of modulation, Power Management

Data link layer- Fundamentals of wireless MAC protocols, Characteristics of MAC protocol in wireless sensor networks contention-based protocols, Contention free MAC protocols,Hybrid MAC protocols

Network layer-routing metrics-Flooding and gossiping, Data centric routing, proactive routing on demand routing, hierarchical routing, Location based routing, QOS based routing. Data Aggregation – Various aggregation techniques.

Case study-Target detection tracking, Habitat monitoring, Environmental disaster monitoring, Practical implementation issues, IEEE 802.15.4 low rate WPAN, Operating System Design Issues. Simulation tools.

Text Books

1. *W. Dargie,C. Poellabauer, "Fundamentals of Wireless sensor networks-Theory and Practice", John Wiley & Sons Publication2010*
2. *K. Sohraby, D.Minoli and T.Znati, "Wireless Sensor Network Technology- Protocols and Applications", John Wiley & Sons, 2007.*

Reference Books

1. *F.Zhao, L.Guibas, "Wireless Sensor Networks: an information processing approach", Elsevier publication, 2004.*
2. *C.S.Raghavendra Krishna,M.Sivalingam and Taribznati, "Wireless Sensor Networks", Springer publication,2004.*
3. *H. Karl, A.willig, "Protocol and Architecture for Wireless Sensor Networks", John Wiley publication, Jan2006.*
4. *K.Akkaya and M.Younis, "A Survey of routing protocols in wireless sensor networks", Elsevier Adhoc Network Journal, Vol.3, no.3, pp. 325-349, 2005.*
5. *Philip Levis, "TinyOS Programming", 2006 –www.tinyos.net.*
6. *I.F. Akyildiz, W. Su, Sankara subramaniam, E. Cayirci, "Wireless sensor networks: a survey", computer networks, Elsevier, 2002, 394 -422.*
7. *Jamal N. Al-karaki, Ahmed E. Kamal, "Routing Techniques in Wireless sensor networks: A survey", IEEE wireless communication, December 2004, 6 –28.*
8. *Recent literature in Wireless Sensor Networks.*

Course outcomes

At the end of the course student will be able

CO1: analyze the challenges and constraints of wireless sensor network and its subsystems

CO2: examine the physical layer specification, modulation and transceiver design considerations

CO3: analyze the protocols used at the MAC layer and scheduling mechanisms

CO4: compare and analyse the types of routing protocols and data aggregation techniques

CO5: identify the application areas and practical implementation issues.

Course Code	**:**	**ECOE19**
Course Title	**:**	**ARM SYSTEM ARCHITECTURE**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**OE**

Course learning Objective

- The objective of this course is to give the students a thorough exposure to ARM architecture and make the students to learn the ARM programming & Thumb programming models.

Course Content

RISC machine. ARM programmer's model. ARM Instruction Set. Assembly level language programming. Development tools.

ARM organization. ARM instruction execution. ARM implementation. ARM coprocessor interface. Flynn's Taxonomy, SIMD and Vector Processors, Vector Floating Point Processor (VFP), VFP and ARM interactions, vector operation.

Floating point architecture. Expressions. Conditional statements. Loops. Functions and procedures. Run time environment. Interrupt response. Interrupt processing. Interrupt Handling schemes, Examples of Interrupt Handlers.

Thumb programmer's model. Thumb Instruction set. Thumb implementation. AMBA Overview, Typical AMAB Based Microcontroller, AHB bus features, AHB Bus transfers, APB bus transfers and APB Bridge.

Memory hierarchy. Architectural support for operating system. Memory size and speed. Cache memory management. Operating system. ARM processor chips. Features of Raspberry Pi and its applications.

Text Books

1. *S. Furber, "ARM System Architecture", Addison-Wesley, 1996.*
2. *Sloss, D.Symes & C.Wright, "ARM system Developer's guide-Designing and Optimizing System Software", Elsevier.2005.*

Reference Books

1. *Technical reference manual for ARM processor cores, including Cortex, ARM 11, ARM 9 & ARM 7 processor families.*
2. *User guides and reference manuals for ARM software development and modelling tools. David Seal, ARM Architecture Reference Manual, Addison-Wesley.*
3. *The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors, Third Edition by Joseph Yiu, Elsevier 2015*
4. *Recent literature in ARM System Architecture.*

Course outcomes

At the end of the course student will be able to

CO1: understand the programmer's model of ARM processor and test the assembly level programming.

CO2: analyze various types of coprocessors and design suitable co-processor interface to ARM processor.

CO3: analyze floating point processor architecture and its architectural support for higher level language.

CO4: become aware of the Thumb mode of operation of ARM.

CO5: identify the architectural support of ARM for operating system and analyze the function of memory Management unit of ARM.

Course Code	**:**	**ECOE20**
Course Title	**:**	**LOW POWER VLSI CIRCUITS**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECPC23**
Course Type	**:**	**OE**

Course learning Objective

- To expose the students to the low voltage device modelling, low voltage, low power VLSI CMOS circuit design.

Course content

CMOS fabrication process, Shallow trench isolation. Lightly-doped drain. Buried channel. Fabrication process of BiCMOS and SOI CMOS technologies.

Modeling of CMOS devices parameters. Threshold voltage, Body effect, Short channel and Narrow channel effects, Electron temperature, and MOS capacitance.

CMOS inverters, static logic circuits of CMOS, pass transistor, BiCMOS, SOI CMOS and low power CMOS techniques.

Basic concepts of dynamic logic circuits. Various problems associated with dynamic logic circuits. Differential, BiCMOS and low voltage dynamic logic circuits.

CMOS memory circuits, Decoders, sense amplifiers, SRAM architecture. Low voltage SRAM techniques.

Text Books

1.Jan Rabaey,"Low Power Design Essentials (Integrated Circuits and Systems)", Springer,2009
2.J.B.Kuo&J.H.Lou,"Low-voltage CMOS VLSI Circuits", Wiley, 1999.

Reference Book

1.A.Bellaowar&M.I.Elmasry,"Low power Digital VLSI Design, Circuits and Systems", Kluwer, 1996.
2.Recent literature in Low Power VLSI Circuits.

Course outcomes

At the end of the course student will be able

CO1: acquire the knowledge about various CMOS fabrication process and its modeling.
CO2: infer about the second order effects of MOS transistor characteristics.
CO3: analyze and implement various CMOS static logic circuits.
CO4: learn the design of various CMOS dynamic logic circuits.
CO5: learn the different types of memory circuits and their design.

Course Code	**:**	**ECOE21**
Course Title	**:**	**COMPUTER VISION AND MACHINE LEARNING**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**OE**

Course Learning Objectives

- Be familiar with the theoretical aspects of computing with images;
- Describe the foundation of image formation, measurement, and analysis;

Course Content

Computer Vision and Computer Graphics, Computer Vision - Low-level, Mid-level, High-level, Diverse Computer Vision Applications: Document Image Analysis, Biometrics, Object Recognition, Tracking, Medical Image Analysis, Content-Based Image Retrieval, Video Data Processing.

Segmentation -Object Recognition, Activity Recognition, and Gesture Recognition - Image features: Colour, Shape, Texture Shape orientation descriptors – SIFT, SURF, Viola Jones Feature detectors, Harris. Integral Histogram.

Adaboost: concept of ensemble of classifiers; basic algorithm; case study- Face detection Artificial Immune Systems Fuzzy belief networks, Evolving belief networks Bayesian belief networks Evolutionary and swarm-based neural networks.

Machine learning: classification, Machine learning: clustering, Machine learning: classification. Logistic regression Bayesian logistic regression Non-linear logistic regression Dual logistic regression Kernel logistic regression, Incremental fitting and boosting.

Reinforcement learning - Classification trees- Multi-class logistic regression Random trees, Random forests, Applications. Introduction to Deep Learning.

Text Books

1. *Richard Szeliski, "Computer Vision: Algorithms and Applications", Springer, 2010.*
2. *D. Forsyth and J. Ponce,"Computer Vision - A modern approach", Prentice Hall, 2002.*

Reference Books

1. *Richard Hartley and Andrew Zisser man, Multiple view geometry in computer vision 2nd edition, Cambridge University press, 2004.*
2. *E Davies, "Computer and Machine Vision, Algorithms, Practicalities", 4th Edition, Elsevier, 2012.*

Course outcomes

At the end of the course student will be able

CO1: learn the basics of computer vision.
CO2: learn the vision features.
CO3: understand issue of segmentation in computer vision algorithms.
CO4: study the basics of Machine learning.
CO5: know the design of Deep learning architectures.

Course Code	**:**	**ECOE22**
Course Title	**:**	**TEXT DATA MINING**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**OE**

Course Learning Objective

- To understand the role played by text mining in Information retrieval and extraction.

Course content

Data, information and knowledge, Models of knowledge representation information retrieval and data mining -relevance, association rules, and knowledge discovery. Conceptual models of an information retrieval and knowledge discovery system.

Information extraction- prediction and evaluation-Textual information to numerical vectors - Types and tokens, Document similarity Vector space models, TF-IDF weighting Indexing, Boolean search Evaluation of IR systems Ranked retrieval Relevance feedback.

Text Categorization – Definition – Document Representation –Feature Selection - Decision Tree Classifiers - Rule-based Classifiers - Probabilistic and Naive Bayes Classifiers - Linear Classifiers- Clustering –Definition- Distance-based Algorithms- Word and Phrase-based Clustering -Semi-Supervised Clustering - Transfer Learning. Naive Bayes - k Nearest Neigh bor (kNN) - Logistic Regression-Decision Trees. Connectivity-based clustering and centroid-based clustering.

Probabilistic Models for Text Mining -Mixture Models - Stochastic Processes in Bayesian Nonparametric Models - Graphical Models - Relationship Between Clustering, Dimension Reduction and Topic Modelling - Latent Semantic Indexing - Probabilistic Latent Semantic Indexing -Latent Dirichlet Allocation- Probabilistic Document Clustering and Topic Models - Probabilistic Models for Information Extraction - Hidden Markov Models- Maximal Entropy Modelling - Maximal Entropy Markov Models -Conditional Random Fields.

Visualization Approaches - Architectural Considerations - Visualization Techniques in Link Analysis - Example- Mining Text Streams - Text Mining in Multimedia - Text Analytics in Social Media - Opinion Mining and Sentiment Analysis - Document Sentiment Classification Aspect-Based Sentiment Analysis - Opinion Spam Detection – Text Mining Applications and Case studies.

Text Books

1. *Sholom Weiss, Nitin Indurkhya, Tong Zhang, Fred Damerau "The Text Mining Handbook: Advanced Approaches in Analyzing Unstructured Data", Springer, paperback 2010.*
2. *Ronen Feldman, James Sanger -" The Text Mining Handbook: Advanced Approaches in Analyzing Unstructured Data"-Cambridge University press, 2006.*

Reference Books

1. *Charu C. Aggarwal, Cheng Xiang Zhai, Mining Text Data, Springer; 2012.*

Course Outcomes

Upon completion of the course, the students will be able to

CO1: know about the basics of text mining.
CO2: Identify the different features that can be mined from text and web documents.
CO3: learn about text classification.
CO4: learn to improve the efficiency of features and reduce the dimensionality.
CO5: understand the basics of recent advances in text classification.

Course Code	**:**	**ECOE23**
Course Title	**:**	**INTERNET OF THINGS**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**CSIR11, C/C++ and Python Programming skills**
Course Type	**:**	**OE**

Course Learning Objective

- To understand basics of an IOT System, IoT sensors, IoT hardware and communication protocols, data storage, data analysis and use them for real time IoT enabled domains.

Introduction to IoT and IoT levels

Functional blocks of an IoT system - Basics of Physical and logical design of IoT - IoT enabled domains - Difference between IoT, Embedded Systems and M2M - Industry 4.0 concepts

IoT sensors and hardware

Passive and active sensors - Different applications of sensors - Multi-sensors - Pre-processing - IoT front-end hardware

Introduction to IoT protocols

Infrastructure - Communication/ Transport - Data Protocols: MQTT, CoAP, AMQP, Websocket, Node

IoT Cloud and data analytics

Collecting data from sensors - Data Ingress - Cloud storage - Data analytics for IoT - Software and management tool for IoT - Dashboard design

IoT architectures with case studies

Business models for IoT - smart cities – agriculture – healthcare - industry.

Case studies/Mini projects for the real time IoT applications.

Text Books

1. Arshdeep Bahga, Vijay Madisetti, "Internet of Things – A hands-on approach", Universities Press, 2015.

Reference Books

1. *Raj kamal, Internet of Things, Architecture and Design Principles, McGraw-Hill, 2017*
2. *Manoel Carlos Ramon, "Intel® Galileo and Intel® Galileo Gen 2: API Features and Arduino Projects for Linux Programmers", Apress, 2014.H.Gerez, "Algorithms for VLSI Design Automation", John Wiley, 1999.*
3. *Marco Schwartz, "Internet of Things with the Arduino Yun", Packt Publishing, 2014.*

COURSEOUTCOMES

Students are ableto

CO1: understand basic premise of an IOT System

CO2 : be familiar with the sensors available for IoT applications

CO3 : learn the front-end hardware platforms and communication protocols for IoT.

CO4 : understand cloud storage, data analysis and management

CO5 : usage for real time IoT enabled domains

Course Code	**:**	**ECOE76**
Course Title	**:**	**Computer Vision**
Number of Credits	**:**	**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**OE**

COURSE OBJECTIVE

- The focus of this course is the understanding of algorithms and techniques used in computer vision.
- Provide pointers into the literature and exercise a project based on a literature search and one or more research papers.
- Practice software implementation of different concepts and techniques covered in the course.
- Utilize programming and scientific tools for relevant software implementation.

COURSE CONTENT

Introduction: overview of computer vision, related areas, and applications; overview of software tools; overview of course objectives.; introduction to OpenCV. Image formation and representation: imaging geometry, radiometry, digitization, cameras and projections, rigid and affine transformations, Filtering: convolution, smoothing, differencing, and scale space

Feature detection: edge detection, corner detection, line and curve detection, active contours, SIFT and HOG descriptors, shape context descriptors, Model fitting: Hough transform, line fitting, ellipse and conic sections fitting, algebraic and Euclidean distance measures.

Camera calibration: camera models; intrinsic and extrinsic parameters; radial lens distortion; direct parameter calibration; camera parameters from projection matrices; orthographic, weak perspective, affine, and perspective camera models.

Motion analysis: the motion field of rigid objects; motion parallax; optical flow, the image brightness constancy equation, affine flow; differential techniques; feature-based techniques; regularization and robust estimation; motion segmentation through EM, Motion tracking: statistical filtering; iterated estimation; observability and linear systems; the Kalman filter; the extended Kalman filter

Object recognition and shape representation: alignment, appearance-based methods, invariants, image Eigen spaces, data-based techniques.

Text Books

4. *Computer Vision: Algorithms and Applications, R. Szeliski, Springer, 2011.*
5. *Computer Vision: A Modern Approach, D. Forsyth and J. Ponce, Prentice Hall, 2nd ed., 2011.*
6. *Introductory techniques for 3D computer vision, E. Trucco and A. Verri, Prentice Hall, 1998.*

COURSE OUTCOMES

Students are able

CO1: To understand the fundamental problems of computer vision.
CO2: To learn techniques, mathematical concepts and algorithms used in computer vision to facilitate further study in this area.
CO3: To get an idea regarding the camera calibration and its importance.
CO4: To study different kinds of motion estimation methodologies and its applications.
CO5: To understand the basic concepts of object and shape recognition techniques

Course Code	**:**	**ECOE77**
Course Title	**:**	**Natural Language Processing**
Number of Credits	**:**	**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**OE**

COURSE LEARNING OBJECTIVE

- Understand NLP tasks in syntax, semantics and pragmatics
- Implement machine learning techniques used in NLP

Introduction – Why NLP? NLP versus speech recognition- Applications-problem of ambiguity- role of machine learning in NLP- Basic neural networks for NLP

Words – Morphology and Finite State transducers-Tokenization – Computational Phonology and Pronunciation Modelling

Probabilistic models in NLP—Role of language models- Simple N-gram model – Evaluation: Perplexity and Word Error Rate. Parts of Speech Tagging- Hidden markov models–Viterbi algorithm, Maximum Entropy Markov model

Semantic analysis - Lexical semantics and word-sense disambiguation. Compositional semantics. Semantic Role Labeling and Semantic Parsing

Machine Translation- Statistical translation, word alignment, phrase-based translation, and synchronous grammars, evaluation.

Reference Books

1. Natural Language Processing, by Jacob Eisenstein, MIT Press.
2. Speech and Language Processing by Daniel Jurafsky and James H. Martin
3. Foundations of Statistical Natural Language processing by Manning C. D. and Schutze H., First Edition, MIT Press, 1999
4. Neural Network Methods for Natural Language Processing by Yoav Goldberg, Morgan & Claypool Publishers.

COURSE OUTCOMES

Students are able to
CO1: Understand NLP and the role of machine learning in NLP
CO2: Describe finite state transducer operations and pronunciation modelling in NLP
CO3: Illustrate various probabilistic models in NLP.
CO4: Study semantic analysis in NLP
CO5: Learn various machine translation approaches and the different evaluation metrics.

Course Code	**:**	**ECOE78**
Course Title	**:**	**Optimization Methods In Machine Learning**
Number of Credits	**:**	**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**OE**

COURSE LEARNING OBJECTIVE

- The course aims to equip students with advanced techniques and methods in optimization that are tailored to large-scale statistics and machine learning problems

COURSE CONTENT

Basics of convex optimization-convex sets, convexity-preserving operations, examples of convex programs (linear programming (LP), second-order cone programming (SOCP), semidefinite programming (SDP)), convex relaxation, KKT conditions, duality

Gradient-based methods-gradient descent, subgradient, mirror descent, Frank–Wolfe method, Nesterov's accelerated gradient method, ODE interpretations, dual methods, Nesterov's smoothing, proximal gradient methods, Moreau–Yosida regularization

Operator splitting methods-augmented Lagrangian methods, alternating direction method of multipliers (ADMM), monotone operators, Douglas–Rachford splitting, primal and dual decomposition

Stochastic and nonconvex optimization-dualaveraging, Polyak–Juditsky averaging, stochastic variance reduced gradient (SVRG), Langevin dynamics, escaping saddle points, landscape of nonconvex problems, deep learning

Applications of optimization methods in Image/Video/Multimedia Processing

Textbooks:

6. *Stephen Boyd and Lieven Vandenberghe's book: Convex Optimization*
7. *Nesterov's old book: Introductory Lectures on Convex Optimization: A Basic Course*
8. *Nesterov's new book: Lectures on Convex Optimization*
9. *Neal Parikh and Stephen Boyd's monograph: Proximal Algorithms*
10. *Sebastien Bubeck's monograph: Convex Optimization: Algorithms and Complexity*

References

5. *Moritz Hardt's Berkeley EE 227C course note*
6. *Prateek Jain and Purushottam Kar's survey on nonconvex optimization*
7. *Kristin Bennett, Emilio Parrado-Hernandez. Interplay of Optimization and Machine Learning Research, Journal of Machine Learning Research, 2006.*
8. *Nati Srebro, Ambuj Tewari. Stochastic Optimization for Machine Learning, Tutorial at International Conference on Machine Learning, 2010.*

COURSE OUTCOMES

Students are able

CO1: To learn the basic concepts of convex optimization

CO2: To study gradient based optimization techniques

CO3: To understand the problem solving using operator splitting methods

CO4: To learn stochastic and non-convex optimization Techniques,

CO5: To execute applications of optimization techniques in different domains

Course Code	**:**	**ECOE79**
Course Title	**:**	**Hardware for Deep Learning**
Number of Credits	**:**	**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**OE**

COURSE LEARNING OBJECTIVE

To get an idea about deep learning and how to implement deep learning algorithms on FPGA

COURSE CONTENT

Introduction to Deep Learning: From AI to DL, Neural Network: Perceptrons, Back Propagation, Over-fitting, Regularization. Deep Networks: Definition, Motivation, Applications, Convolution Neural Network (CNN): Basic architecture, Activation functions, Pooling, Handling vanishing gradient problem, Dropout, Weight initialization methods, Batch Normalization. Training Neural networks, Additional CNN Components, Famous CNNs, Applications, Software libraries.

Computing Convolutions: Mapping Matrix multiplication, Computational Transforms, Accelerator Architectures, Dataflow Taxonomy

Reducing the Complexity: Light weight models, reducing precision, Aggressive Quantization, pruning & Deep compression.

The Deep Learning Acceleration Landscape: parallelism in deep learning, Traditional programmable hardware, specialized deep learning hardware platforms, deep learning software stack, Specialized research ASICs.

FPGAs for Deep Learning: Overview of hardware architectures for deep learning, Effective management of FPGA memory resources, optimizing algorithms and data representation for FPGA arithmetic resources, Integrating hardware and software.

Text Books

4. *Ian Goodfellow, Yishuv Bengio and Aaron Courville, "Deep Learning." MIT Press. 2016. ISBN: 978-0262035613. Available online for free at: http://www.deeplearningbook.org*
5. *Vivienne Sze; Yu-Hsin Chen; Tien-Ju Yang; Joel S. Emer, "Efficient Processing of Deep Neural Networks" Morgan & Claypool Publishers, 1st Edition, 2020.*
6. *Tushar Krishna, Hyoukjun Kwon, Angshuman Parashar, Michael Pellauer, and Ananda Samajdar, "Data Orchestration in Deep Learning Accelerators", Morgan & Claypool Publishers, 1st Edition, 2020.*

References

7. *Piotr Antonik, "Application of FPGA to Real-Time Machine Learning", Springer, 2018.*
8. *Stanford C231n, 2017*
9. *Sze, et al. https://eyeriss.mit.edu/ ISCA Tutorial 2019*
10. *Sze, et al. "Efficient Processing of Deep Neural Networks: A Tutorial and Survey", Proceedings of the IEEE, 2017*
11. *Prof. Adam Teman https://www.eng.biu.ac.il/temanad/hardware-for-deep-learning/*
12. *https://jameswhanlon.com/*

Course outcomes

Students are able to

CO1: Understand the context of convolutional neural networks and deep learning algorithms.

CO2: Know how to use convolution in deep learning techniques.

CO3: Understand the necessity and importance of light weight models with low complexity through specialized hardware architecture

CO4: Know how to optimize hardware performance in deep neural network applications.

CO5: Discuss, suggest and evaluate specialised hardware architectures to implement deep learning algorithms in FPGA and utilise deep learning concepts in resource constrained reliable systems.

Course Code	**:**	**ECOE80**
Course Title	**:**	**Image and Video Processing**
Number of Credits	**:**	**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**OE**

COURSE LEARNING OBJECTIVE

- The course aims to equip students with basic image and video processing techniques.

COURSE CONTENTS

Image Formation and Representation: 3D to 2D projection, photometric image formation, trichromatic colour representation, video format (SD, HD, UHD, HDR), contrast enhancement (concept of histogram, nonlinear mapping, histogram equalization)

Review of 1D Fourier transform and convolution: Concept of spatial frequency. Continuous and Discrete Space 2D Fourier transform. 2D convolution and its interpretation in frequency domain. Implementation of 2D convolution. Separable filters. Frequency response. Linear filtering (2D convolution) for noise removal, image sharpening, and edge detection. Gaussian filters, DOG and LOG filters as image.

Geometric mapping and Feature detection: Geometric mapping (affine, homography), Feature based camera motion estimation (RANSAC). Image warping. Image registration. Panoramic view stitching, Feature detection (Harris corner, scale space, SIFT), feature descriptors (SIFT). Bag of Visual Word representation for image classification.

Motion estimation: optical flow equation, optical flow estimation (Lucas-Kanade method, KLT tracker); block matching, multi-resolution estimation. Deformable registration (medical applications), Moving object detection (background/foreground separation): Robust PCA (low rank + sparse decomposition). Global camera motion estimation from optical flows. Video stabilization. Video scene change detection.

Video Coding: block-based motion compensated prediction and interpolation, adaptive spatial prediction, block-based hybrid video coding, rate-distortion optimized mode selection, rate control, Group of pictures (GoP) structure, tradeoff between coding efficiency, delay, and complexity, depth from disparity, disparity estimation, view synthesis. Multiview video compression. Depth camera (Kinect). 360 video camera and view stitching.

Text Book/References:

1. *Richard Szeliski, Computer Vision: Algorithms and Applications. (Available online:"Link") (Cover most of the material, except sparsity-based image processing and image and video coding)*
2. *(Optional) Y. Wang, J. Ostermann, and Y.Q.Zhang, Video Processing and Communications. Prentice Hall, 2002. "Link" (Reference for image and video coding, motion estimation, and stereo)*
3. *(Optional) R. C. Gonzalez and R. E. Woods, Digital Image Processing, Prentice Hall, (3rd Edition) 2008. ISBN number 9780131687288. "Link" (Good reference for basic image processing, wavelet transforms and image coding).*

COURSE OUTCOMES

Students are able to

CO1: Understand the concept of image formation and representation

CO2: Know the need of transformation and convolution

CO3: Understand the necessity and importance of feature detection and geometric mapping

CO4: Know how to do motion estimation in video

CO5: To understand the basic ideas of video coding

Course Code	**:**	**ECOE81**
Course Title	**:**	**Automated Test Engineering for Electronics**
Number of Credits	**:**	**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**OE**

COURSE CONTENT

Printed Circuit Boards (PCBs) – types of PCB – multilayer PCBs – Plated though Hole Technology (PTH) - Surface Mount Technology (SMT) – Ball Grid Array (BGA) Technology. Bare PCB electrical test concepts, Loaded PCB Visual inspection, Automated Optical inspection systems, X-Ray inspection systems- Measuring Passive components – 2 wire, 3 wire, 4 wire and 6 wire measurement concepts, Guarding techniques, Shorts location, Most common manufacturing defects, Automated Manufacturing defect analyzers, Nodal Impedance / analog signature analysis. Flying probe testers.

Concepts of PCB Trouble-shooting, Symptom recognition, Bracketing technique, Failure types and fault causes, Manual Trouble shooting, Use of DMM, Oscilloscope, Signal Generators, Logic Probes, Logic Pulsers, Logic Analyzers, Automated Test Techniques – CPU Emulation technique, ROM Emulation, In-Circuit Comparators, In- Circuit Emulators, Functional Testing of Digital ICs, Library models, Concepts of In-circuit Testing, - Back Driving technique – international defence standards - Auto Compensation, In-Circuit Test of Open collector / Emitter Devices, Tri-State, Bi-Directional Devices, Concepts of Digital Guarding, Analog and Mixed Signal ICs Test, advantages and limitations of in-circuit testing, AC – DC Parametric testing, –Advanced test techniques- Boundary Scan Test , Learn and compare technique – digital signatures, Bus Cycle Signature Test , Analog signatures.

ATE system components, Main Test Vector processor, Digital Subsystem, Pin Electronics, Programmable drive and threshold levels, RAM behind each pin, Controlling slew rate, Skew between channels, Data formats, Digital and analog simulation, Test Vector Generation, Fault simulation, Fault coverage, Test Languages, Verilog, VHDL, Automatic compare, Analog Sub system, Digital and analog matrix switch circuits, digital and analog highways, Integration of JTAG, Boundary Scan Test, BSDL, External Instrumentation, Functional and Timing tests.

Concepts of Test Program (T.P) Generation. Commercially available off the shelf Test Equipment's (COTS)

Board Functional Test (BFT) techniques – Go-No-go Test – Diagnostic Test, Reliability Test, Thermal Shock Test, Full functional Edge to edge test, Cluster Test – Guided Probe Backtracking Technique – Simulators – Online and Offline Simulation - Fault Simulation– Comprehensiveness of Board program – Fault Dictionary– Analysis – BS and Non-BS device testing–- Sample board programming and testing – BS interconnect and simulating faults - External Instrumentation used for board testing – PXI Instrumentation – Integration of PXI instruments for testing

Design for testability (DFT) and Design for manufacturability (DFM) - Basics of ATPG, – Fault Models – – Design considerations for edge functional test, Design considerations for Bus Cycle Signature Test, Design considerations for Boundary Scan Test, Built-in Self Test, Modular Design,– ATE for test - DFM - Manufacturing phases in industry oriented Production process – strategies – new strategy - benefits of new strategies

Reference Books:

1. *Test Engineering for Electronic Hardware – S R Sabapathi, Qmax Test Equipments P Ltd., 2011*
2. *Practical Electronic Fault Finding and Trouble shooting - Robin Pain Newnes, Reed Educational and professional publishing Ltd., 1996*
3. *The Fundamentals of Digital Semiconductor Testing, Floyd, Pearson Education India, Sep-2005*
4. *Building a Successful Board Test Strategy-Stephen F Scheiber-Butterworth Heinemann*

COURSE OUTCOMES

Students are able to

CO1: Understand PCB and various manufacturing techniques.
CO2: Understand common PCB failure detection techniques.
CO3: Understand the various ATE system components.
CO4: Know different board functional test techniques.
CO5: Understand the basic considerations for design manufacturability and testability.

Course Code	**:**	**ECOE82**
Course Title	**:**	**Foundations of Artificial Intelligence**
Number of Credits	**:**	**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**OE**

COURSE LEARNING OBJECTIVE

- Approaches to produce "intelligent" systems, Knowledge representation (both symbolic and neural network), search and machine learning.
- To learn the principles and fundamentals of designing AI programs.

Introduction to AI-Problem Solving as State Space Search, Uniformed Search, Heuristic Search, Informed Search, Constraint Satisfaction Problems, Searching AND/OR Graphs.

Knowledge representation and Reasoning-Introduction to Knowledge Representation, Propositional Logic, First Order Logic –I, First Order Logic –II, Inference in First Order Logic-I, Inference in First Order Logic – II, Answer Extraction, Procedural Control of Reasoning, Reasoning under Uncertainty, Bayesian Network, Decision Network.

Planning and decision Making-Introduction to Planning, Plan Space Planning, Planning Graph and Graph Plan, Practical Planning and Acting, Sequential Decision Problems, Making Complex Decisions.

Machine Learning-Introduction to Machine Learning, Learning Decision Trees, Linear Regression, Support Vector Machines, Unsupervised Learning, Reinforcement Learning,

Introduction to deep learning, neural network learning

<u>Text Books</u>

1. Patrick Henry Winston, Artificial Intelligence, Third Edition, Addison-Wesley Publishing Company, 2004.

2. Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach, 3rd Edition, PHI 2009.

<u>References</u>

1. Nils J Nilsson, Principles of Artificial Intelligence, Illustrated Reprint Edition, Springer Heidelberg, 2014.

2. Nils J. Nilsson, Quest for Artificial Intelligence, First Edition, Cambridge University Press, 2010.

COURSE OUTCOMES

Students are able

CO1: To learn the concepts of artificial intelligence

CO2: To study problem solving techniques

CO3: To understand the representation of knowledge and reasoning mechanism

CO4: To learn to panning and decision making

CO5: To study network models used for learning

Course Code	**:**	**ECOE83**
Course Title	**:**	**Photonic Integrated Circuits**
Number of Credits	**:**	**3**
Course Type	**:**	**OE**

COURSE LEARNING OBJECTIVES

- The photonic integrated circuits course will introduce the basics of integrated optical waveguides used in optical communication applications.
- To introduce the concept reconfigurable architecture design in Photonic circuits
- To understand and realize Application-Specific Photonic Integrated Circuits and devices for Classical Applications
- This course also covers materials and fabrication technology for optical integrated circuits.

COURSE CONTENT

Brief history of optical communication, Advantages of integrated optics configuration, Guided TE and TM Modes of Symmetric and anti-symmetric planar waveguides: Step-index and graded-index waveguides. Strip and channel waveguides, Beam propagation method.

Directional couplers, Applications as power splitters, Y-junction, optical switch; modulators, filters, A/D converters, Mode splitters, Mach-Zehnder interferometer based devices.

Acousto-optic waveguide devices. Arrayed waveguide devices, Nano-photonic-devices: Metal/dielectric plasmonic waveguides, Surface Plasmon modes, applications in waveguide polarizers.

Materials. Glass, lithium niobate, silicon, compound semiconductors. Fabrication of integrated optical waveguides and devices. Lithography, deposition.

Waveguide characterisation, prism coupling, grating and tapered couplers, Nonlinear effects in integrated optical waveguides, Types and Applications.

Text Books

4. *H Nishihara, M Haruna and T Suhara, Optical Integrated Circuits; McGraw-Hill Book Company, New York, 1989.*
5. *C. R. Pollock and M Lipson, Integrated photonics, Kluwer Pub, 2003.*
6. *José Capmany and Daniel Pérez, Photonic Integrated Circuits, Oxford Univversity Press, 2020*

Reference Books

6. *A Ghatak and K Thyagarajan, Optical Electronics, Cambridge University Press, 1989.*
7. *T. Tamir, Guided wave opto-electronics, Springer Verilag, 1990*
8. *K. Okamota, Fundamentals of Optical waveguides, Academic Press, 2006.*
9. *T. Tamir, Integrated Optics, Springer Verlag, New York, 1982.*
10. *Recent journals and conference proceedings.*

Course outcomes

At the end of the course student will be able

CO1: Summarize the fundamental concept of optical waveguides.

CO2: Construct the different types of optical waveguides.

CO3: Construct the couplers, modulators and devices for communication applications

CO4: Summarize fabrication technologies for design of optical waveguides

CO5: Describe the various nonlinear effects in integrated optical waveguides.

Course Code	**:**	**ECOE84**
Course Title	**:**	**Microwave Circuits**
Number of Credits	**:**	**3**
Course Type	**:**	**OE**

COURSE OBJECTIVE

• To make the students familiarize with ABCD parameters, S parameters, Applications of planar transmission lines in the practical microwave circuits, Design and layout of all Microwave Integrated Circuit Design components and then systems.

COURSE CONTENT

Introduction and application of microwave circuits - Two-port network characterization. ABCD parameters, Conversion of S matrix in terms of ABCD matrix. Scattering matrix representation of microwave components. Review of Smith chart and its application- Impedance matching using Lumped and Distributed approach.

Microwave Passive circuit design: Characteristics, properties, design parameters and applications-Design and realization of MIC Power dividers. 3 dB hybrid design. Directional Coupler design-Hybrid ring design.

Microwave filter design- Filter design by insertion loss method –Richards and Kuroda transformation. K inverter, J inverter. Resonator filters. Realization using microstrip lines and strip lines.

Microwave amplifier design- Power gain equations -Stability considerations. Maximum gain design, Design for specific gain -Low Noise Amplifier Design. High power design.

Microwave oscillator design. One – port and two – port negative resistance oscillators and oscillator design

Text Books:

1. *Reinhold Ludwig, RF circuit design, 2nd edition, Prentice Hall 2014, ISBN: 978-0131471375*
2. *David. M. Pozar, Microwave engineering, 4th edition, John Wiley, 2011, ISBN: 978-0470631553.*
3. *Devendra K. Misra, "Radio-Frequency and microwave communication circuits analysis and design", 2nd edition, University of Wisconsin-Mulwaukee, A John Wiley & Sons Publication*

Reference Books:

1. *B. Bhat, S. K Koul, "Stripline like transmission lines for Microwave Integrated Circuits", New Age International Pvt. Ltd Publishers, 2007.*
2. *I.J.Bahl & P.Bhartia, "Microwave Solid state Circuit Design (2/e)", Wiley, 2003.*
3. *Matthew M. Radmanesh, Radio Frequency and Microwave Electronics Illustrated, Prentice Hall, 2012*
4. *S.Y.Liao, "Microwave Circuit Analysis and Amplifier Design", Prentice-Hall, 1986.*
5. *G. Mathaei, L young, E.M.T. Jones, "Microwave filters, Impedance-Matching networks and Coupling structures", Artech House Books.*

COURSE OUTCOMES

Students are able to

CO1: Understand the basics of Scattering matrix and two port characterization and importance of matching circuits.

CO2: Analyze the working principles of couplers, power dividers etc. and their design.

CO3: Design the different types of MIC filters and their implementation.

CO4: Understand the complexities of microwave amplifier design and its stability features.

CO5: Analyze and appreciate the design principles of microwave oscillators.

Course Code	**:**	**ECMI10**
Course Title	**:**	**SIGNALS AND SYSTEMS**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**MI**

Course Learning Objectives

- To make the students to understand the fundamental characteristics of signals and systems in terms of both the time and transform domains
- Development of the mathematical skills to solve problems involving convolution, filtering, modulation and sampling.

Course Content

Definition of Signals and Systems, Classification of Signals, Operations on signals, Singularity functions and related functions. Analogy between vectors and signals - orthogonal signal space, complete set of orthogonal functions, Parseval's relations. Fourier series representation of continuous time periodic signals -Trigonometric and Exponential Fourier series- Properties of Fourier series.

Fourier transform of aperiodic signals, standard signals and periodic signals - Properties of Fourier transforms. Hilbert transform and its properties. Laplace transforms-RoC-properties. Inverse Laplace transform.

Continuous-time Systems and its properties. Linear time invariant (LTI) system-Impulse response. Convolution. Analysis of LTI System using Laplace and Fourier transforms.

Sampling and reconstruction of band limited signals. Low pass and band pass sampling theorems. Aliasing. Anti-aliasing filter. Practical Sampling-aperture effect.

Discrete-time signals and systems. Discrete Fourier series. Z-transform and its properties. Analysis of LSI systems using Z – transform.

Text Books

1. *A.V.Oppenheim, A. Willsky, S. Hamid Nawab, "Signals and Systems (2/e)", Pearson 200.*
2. *S.Haykin and B.VanVeen "Signals and Systems, Wiley, 1998.*

Reference Books

1. *M.Mandal and A.Asif, "Continuous and Discrete Time Signals and Systems, Cambridge, 2007.*
2. *D.C.Lay, "Linear Algebra and its Applications (2/e)", Pearson, 200.*
3. *S.S.Soliman & M.D.Srinath, "Continuous and Discrete Signals and Systems", Prentice- Hall, 1990.*

Course outcomes

At the end of the course student will be able to

CO1: Understand the mathematical description and representation of continuous-time and discrete-time signals.

CO2: Analyze the spectral characteristics of continuous-time periodic and aperiodic signals using Fourier analysis.

CO3: Analyse system properties based on impulse response and Fourier analysis

CO4: Convert a continuous time signal into discrete time signal and reconstruct the continuous time signals back from its samples

CO5: Apply the Laplace transform and Z- transform respectively for the analyse of continuous-time and discrete-time signals.

Course Code	**:**	**ECMI11**
Course Title	**:**	**NETWORK ANALYSIS AND SYNTHESIS**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**MI**

Course Learning Objectives

- To make the students capable of analysing any given electrical network.
- To make the students to learn synthesis of an electrical network for a given impedance/ admittance function.

Course Content

Network concept. Elements and sources. Kirchhoff's laws. Tellegen's theorem. Network equilibrium equations. Node and Mesh method. Source superposition. Thevenin's and Norton's theorems. Network graphs.

First and second order networks. State equations. Transient response. Network functions. Determination of the natural frequencies and mode vectors from network functions.

Sinusoidal steady-state analysis. Maximum power-transfer theorem. Resonance. Equivalent and dual networks. Design of equalizers.

Two-port network parameters. Interconnection of two port networks. Barlett's bisection theorem. Image and
Iterative parameters. Design of attenuators.

Two-terminal network synthesis. Properties of Hurwitz polynomial and Positive real function. Synthesis of LC, RC and RL Networks, Foster Forms and Cauer Forms.

Text Books

1. *Hayt W. H., Kemmerly J. E. and Durbin S. M., "Engineering Circuit Analysis", 6th Ed., Tata McGraw-Hill Publishing Company Ltd., 2008.*
2. *F.F. Kuo, "Network analysis and Synthesis", Wiley International Edition, 2008.*

Reference Books

1. *Valkenberg V., "Network Analysis", 3rd Ed., Prentice Hall International Edition, 2007.*
2. *B.S.Nair and S.R.Deepa, "Network analysis and Synthesis", Elsevier, 2012.*

Course outcomes

At the end of the course student will be able

CO1: analyze the electric circuit using network theorems

CO2: understand and Obtain Transient & Forced response

CO3: determine Sinusoidal steady state response; understand the real time applications of maximum power transfer theorem and equalizer

CO4: understand the two–port network parameters, are able to find out two-port network parameters & overall response for interconnection of two-port networks.

CO5: synthesize one port network using Foster form, Cauer form.

Course Code	**:**	**ECMI12**
Course Title	**:**	**ELECTRODYNAMICS AND ELECTROMAGNETIC WAVES**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**MI**

Course Learning Objective

- To expose the students to the rudiments of Electromagnetic theory and wave propagation essential for subsequent courses on microwave engineering, antennas and wireless communication

Course Content

Electrostatics. Coulomb's law. Gauss's law and applications. Electric potential. Poisson's and Laplace equations. Method of images. Multipole Expansion.

Electrostatic fields in matter. Dielectrics and electric polarization. Capacitors with dielectric substrates. Linear dielectrics. Force and energy in dielectric systems.

Magneto statics. Magnetic fields of steady currents. Biot-Savart's and Ampere's laws. Magnetic vector potential. Magnetic properties of matter.

Electrodynamics. Flux rule for motional emf. Faraday's law. Self and mutual inductances. Maxwell's Equations. Electromagnetic Boundary conditions. Poynting theorem.

Electromagnetic wave propagation. Uniform plane waves. Wave polarization. Waves in matter. Reflection and transmission at boundaries. Propagation in an ionized medium.

Text Books

1. *D.J.Griffiths, "Introduction to Electrodynamics (3/e)", PHI, 2001*
2. *E.C. Jordan & G. Balmain, "Electromagnetic Waves and Radiating Systems", PHI, 1995.*

Reference Books

1. *W.H.Hayt, "Engineering Electromagnetics, (7/e)", McGraw Hill, 2006.*
2. *D.K.Cheng, "Field and Wave Electromagnetics, (2/e)", Addison Wesley, 1999.*
3. *M.N.O.Sadiku, "Principles of Electromagnetics, (4/e)", Oxford University Press, 2011.*
4. *N.Narayana Rao, "Elements of Engineering Electromagnetics, (6/e)", Pearson, 2006.*
5. *R.E.Collin, "Foundations for Microwave Engineering (2/e)", McGraw –Hill, 2002.*
6. *R.E.Collin, "Antennas and Radiowave Propagation", McGraw-Hill, 1985.*

Course outcomes

At the end of the course student will be able

CO1: recognize and classify the basic Electrostatic theorems and laws and to derive them.
CO2: discuss the behaviour of Electric fields in matter and Polarization concepts.
CO3: classify the basic Magneto static theorems and laws and infer the magnetic properties of matter.
CO4: summarize the concepts of electrodynamics &to derive and discuss the Maxwell's equations.
CO5: students are expected to be familiar with Electromagnetic wave propagation and wave polarization.

Course Code	**:**	**ECMI13**
Course Title	**:**	**SEMICONDUCTOR PHYSICS AND DEVICES**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**MI**

Course Learning Objective

- To make the students understand the fundamentals of electronic devices.
- To train them to apply these devices in mostly used and important applications.

Course Content

Semiconductor materials: crystal growth, film formation, lithography, etching and doping. Formation of energy bands in solids, Concept of hole, Intrinsic and extrinsic semiconductors, conductivity, Equilibrium Carrier concentration, Density of states and Fermi level, Carrier transport – Drift and Diffusion, continuity equation, Hall effect and its applications.

P-N junction diodes, Energy band diagram, biasing, V-I characteristics, capacitances. Diode models, Break down Mechanisms, Rectifiers, Limiting and Clamping Circuits, types of diodes.

BJT Physics and Characteristics modes of operation, Ebers-Moll Model, BJT as a switch and Amplifier, breakdown mechanisms, Photo devices.

MOSFET: Ideal I-V characteristics, non-ideal I-V effects, MOS Capacitor, MOSFET as switch, CMOS Logic gate Circuits, Bi-CMOS circuits, CCDs.

State-of-the-art MOS technology: small-geometry effects, FinFETs, Ultrathin body FETs. Display devices, Operation of LCDs, Plasma, LED and HDTV

Text Books

1. *S.M.Sze, Semiconductors Devices, Physics and Technology, (2/e), Wiley, 2002*
2. *A.S.Sedra & K.C.Smith, Microelectronic Circuits (5/e), Oxford, 2004*

Reference Books

1. *L.Macdonald & A.C.Lowe, Display Systems, Wiley, 2003Robert Pierret, "Semiconductor Device Fundamentals," Pearson Education, 2006*
2. *J.Millman and C.C.Halkias: Electronic devices and Circuits, McGraw Hill, 1976.*
3. *B.G.Streetman: Solid state devices, (4/e), PHI, 1995.*
4. *N.H.E.Weste, D. Harris, "CMOS VLSI Design (3/e)", Pearson, 2005.*

Course outcomes

At the end of the course student will be able

CO1: Apply the knowledge of basic semiconductor material physics and understand fabrication processes.

CO2: Analyze the characteristics of various electronic devices like diode, transistor etc.,

CO3: Classify and analyze the various circuit configurations of Transistor and MOSFETs.

CO4: Illustrate the qualitative knowledge of Power electronic Devices.

CO5: Become Aware of the latest technological changes in Display Devices.

Course Code	**:**	**ECMI14**
Course Title	**:**	**DIGITAL CIRCUITS AND SYSTEMS**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**MI**

Course Learning Objective

- To introduce the theoretical and circuit aspects of digital electronics, which is the back bone for the basics of the hardware aspect of digital computers

Course Content

Review of number systems-representation-conversions, error detection and error correction. Review of Boolean algebra- theorems, sum of product and product of sum simplification, canonical forms-minterm and maxterm, Simplification of Boolean expressions-Karnaugh map, completely and incompletely specified functions, Implementation of Boolean expressions using universal gates.

Combinational logic circuits- adders, subtractors, BCD adder, ripple carry look ahead adders, parity generator, decoders, encoders, multiplexers, DE multiplexers, Realization of Boolean expressions-using decoders-using multiplexers. Memories – ROM- organization, expansion. PROMs. Types of RAMs – Basic structure, organization, Static and dynamic RAMs, PLDs, PLAs.

Sequential circuits – latches, flip flops, edge triggering, asynchronous inputs. Shift registers, Universal shift register, applications. Binary counters – Synchronous and asynchronous up/down counters, mod-N counter, Counters for random sequence.

Synchronous circuit analysis and design: structure and operation, analysis-transition equations, state tables and state diagrams, Modelling- Moore machine and Mealy machine- serial binary adder, sequence recogniser, state table reduction, state assignment. Hazard; Overview and comparison of logic families.

Introduction to Verilog HDL, Structural, Dataflow and behavioural modelling of combinational and sequential logic circuits.

Text Books

1. *Wakerly J F, "Digital Design: Principles and Practices, Prentice-Hall", 2nd Ed., 2002.*
2. *D. D. Givone, "Digital Principles and Design", Tata Mc-Graw Hill, New Delhi, 2003.*

Reference Books

1. *S.Brown and Z.Vranesic, "Fundamentals of Digital Logic with Verilog Design", Tata Mc-Graw Hill, 2008.*
2. *D.P. Leach, A. P. Malvino, GoutamGuha, "Digital Principles and Applications", Tata Mc-Graw Hill, New Delhi, 2011.*
3. *M. M. Mano, "Digital Design", 3rd ed., Pearson Education, Delhi, 2003.*
4. *R.J.Tocci and N.S.Widner, "Digital Systems - Principles& Applications", PHI, 10th Ed., 2007.*
5. *Roth C.H., "Fundamentals of Logic Design", Jaico Publishers. V Ed., 2009.*
6. *T. L. Floyd and Jain,"Digital Fundamentals", 8th ed., Pearson Education, 2003.*

Course outcomes

At the end of the course student will be able

CO1: Apply the knowledge of Boolean algebra and simplification of Boolean expressions to deduce optimal digital networks.

CO2: Study and examine the SSI, MSI and Programmable combinational networks.

CO3: Study and investigate the sequential networks suing counters and shift registers; summarize the performance of logic families with respect to their speed, power consumption, number of ICs and cost.

CO4: Work out SSI and MSI digital networks given a state diagram based on Mealy and Moore configurations.

CO5: Code combinational and sequential networks using Virology HDL.

Course Code	**:**	**ECMI15**
Course Title	**:**	**DIGITAL SIGNAL PROCESSING**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECMI10**
Course Type	**:**	**MI**

Course Learning Objective

- To study about discrete-time Fourier transform (DTFT), the concepts of frequency response characteristics of a discrete-time systems, DFT and its fast computation.
- To make the students able to design digital filters (FIR and IIR) and implement in various forms.
- To study and understand the concept of multirate DSP systems and its applications

Course Content

Review of LSI system, DTFT, Frequency response of discrete time systems, all pass inverse, linear phase and minimum phase systems.

DFT, Relationship of DFT to other transforms, FFT, DIT and DIF, FFT algorithm, Linear filtering using DFT and FFT.

Characteristics of FIR Digital Filters, types and frequency response - Design of FIR digital filters using window techniques and frequency sampling technique - basic structures and lattice structure for FIR systems.

Analog filter approximations – Butter worth and Chebyshev, Design of IIR Digital filters from analog filters, Analog and Digital frequency transformations - Basic structures of IIR systems, Transposed forms.

Sampling rate conversion by an integer and rational factor, Poly phase FIR structures for sampling rate conversion.

Text Books

1. *J.G.Proakis, D.G. Manolakis, "Digital Signal Processing", (4/e) Pearson, 2007.*
2. *A.V.Oppenheim & R.W.Schafer, "Discrete Time Signal processing", (2/e), Pearson Education, 2003.*

Reference Books

1. *S.K.Mitra, "Digital Signal Processing (3/e)", Tata McGraw Hill, 2006.*
2. *P.S.R.Diniz, E.A.B.da Silva and S.L.Netto, "Digital Signal Processing", Cambridge, 2002.*
3. *E.C.Ifeachor & B.W.Jervis, "Digital Signal Processing", (2/e), Pearson Education, 2002.*
4. *J.R.Jhonson, "Introduction to Digital Signal Processing", Prentice-Hall, 1989.*

Course outcomes

At the end of the course student will be able to

CO1: analyze discrete-time systems in both time & transform domain and also through pole-zero placement.

CO2: analyze discrete-time signals and systems using DFT and FFT.

CO3: design and implement digital finite impulse response (FIR) filters.

CO4: design and implement digital infinite impulse response (IIR) filters.

CO5: understand and develop multirate digital signal processing systems.

Course Code	**:**	**ECMI16**
Course Title	**:**	**TRANSMISSION LINES AND WAVEGUIDES**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECMI12**
Course Type	**:**	**MI**

Course Learning Objective

- To expose students to the complete fundamentals and essential feature of waveguides, resonators and microwave components and also able to give an introduction to microwave integrated circuit design.

Course Content

Classification of guided wave solutions-TE, TM and TEM waves. Field analysis transmission lines.

Rectangular and circular waveguides. Excitation of waveguides. Rectangular and circular cavity resonators.

Transmission line equations. Voltage and current waves. Solutions for different terminations. Transmission-line loading.

Impedance transformation and matching. Smith Chart, Quarter-wave and half-wave transformers. Binomial and T-chebeyshev transformers. Single, double and triple stub matching.

Microstriplines, stripline, slot lines, coplanar waveguide and fin line. Micro strip MIC design aspects. Computer- aided analysis and synthesis.

Text Books

1. *D.M.Pozar, "Microwave Engineering (3/e)" Wiley, 2004.*
2. *J.D.Ryder, "Networks, Lines and Fields", PHI, 2003.*

Reference Books

1. *R.E.Collin, "Foundations for Microwave Engineering (2/e)", McGraw-Hill, 2002.*
2. *S.Y.Liao, "Microwave Devices and Circuits", (3/e) PHI, 2005.*
3. *J. A. Seeger, "Microwave Theory, Components, and Devices" Prentice-Hall-A division of Simon & Schuster Inc Englewood Cliffs, New Jersy 07632, 1986.*

Course outcomes

At the end of the course student will be able

CO1: classify the Guided Wave solutions -TE, TM, and TEM.

CO2: analyze and design rectangular waveguides and understand the propagation of electromagnetic waves.

CO3: evaluate the resonance frequency of cavity Resonators and the associated modal field.

CO4: analyze the transmission lines and their parameters using the Smith Chart.

CO5: apply the knowledge to understand various planar transmission lines.

Course Code	**:**	**ECMI17**
Course Title	**:**	**ELECTRONIC CIRCUITS**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECMI13**
Course Type	**:**	**MI**

Course Learning Objective

- To make the students understand the fundamentals of electronic circuits.

Course Content

Load line, operating point, biasing methods for BJT and MOSFET. Low frequency and high models of BJT and MOSFET, Small signal Analysis of CE, CS, CD and Cascade amplifier

MOSFET amplifiers: Current mirrors: Basic current mirror, Cascade current mirror, Single-ended amplifiers: CS amplifier – with resistive load, diode connected load, current source load, triode load, source degeneration. CG and CD amplifiers, Cascade amplifier,

Frequency response of amplifiers, Differential Amplifiers, CMRR, Differential amplifiers with active load, two stage amplifiers

Feedback concept, Properties, Feedback amplifiers, Stability analysis, Condition for oscillation, Sinusoidal oscillators.

Power amplifiers- class A, class B, class AB, Biasing circuits, class C and class D

Text Books

1. *A.S.Sedra & K.C.Smith, "Microelectronic Circuits (5/e)", Oxford, 2004.*
2. *D.L.Schilling & C.Belove, "Electronic Circuits: Discrete and Integrated", (3/e), McGraw Hill, 1989.*

Reference Books

1. *Behzad Razavi, "Design of Analog CMOS Integrated Circuits", (2/e), McGraw Hill, 2017.*
2. *Millman&A., "Microelectronics", McGraw Hill, 1987.*
3. *K.V.Ramanan, "Functional Electronics", Tata McGraw Hill, 1984.*

Course outcomes

At the end of the course student will be able

CO1: illustrate about rectifiers, transistor and FET amplifiers and its biasing. Also compare the performances of its low frequency models.

CO2: discuss about the frequency response of MOSFET and BJT amplifiers.

CO3: illustrate about MOS and BJT differential amplifiers and its characteristics.

CO4: discuss about the feedback concepts and construct feedback amplifiers and oscillators. Also summarizes its performance parameters.

CO5: explain about power amplifiers and its types and also analyze its characteristics.

Course Code	**:**	**ECMI18**
Course Title	**:**	**MICROPROCESSORS AND MICRO CONTROLLERS**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECMI14**
Course Type	**:**	**MI**

Course Learning Objective

- This subject deals about the basics of 16-bit Microprocessor, 8-bit and 16-bit Micro controllers, their architectures, internal organization and their functions, peripherals, and interfacing.

Course Content

Microprocessor based personal computer system. Software model of 8086. Segmented memory operation. Instruction set. Addressing modes. Assembly language programming. Interrupts. Programming with DOS and BIOS function calls.

Hardware detail of 8086. . Bus timing. Minimum Vs Maximum mode of operation. Memory interface. Parallel and serial data transfer methods. 8255 PPI chip. 8259 Interrupt controller. 8237 DMA controller.

Microcontroller. Von-Neumann Vs Harvard architecture. Programming model. Instruction set of 8051 Microcontroller. Addressing modes. Programming. Timer operation.

Mixed Signal Microcontroller: MSP430 series. Block diagram. Address space. On-chip peripherals - analog and digital. Register sets. Addressing Modes. Instruction set. Programming. FRAM Vs flash for low power and reliability.

Peripheral Interfacing using 8051 and Mixed signal microcontroller. Serial data transfer - UART, SPI and I2C. Interrupts. I/O ports and port expansion. DAC, ADC, PWM, DC motor, Stepper motor and LCD interfacing.

Text Books

1. J.L.Antonakos, "An Introduction to the Intel Family of Microprocessors", Pearson, 1999.

2. M.A.Mazidi & J.C.Mazidi "Microcontroller and Embedded systems using Assembly & C. (2/e)", Pearson Education, 2007.

Reference Books

1.John H. Davies, "MSP430 Microcontroller Basics", Elsevier Ltd., 2008

2.B.B. Brey, "The Intel Microprocessors, (7/e), Eastern Economy Edition", 2006.

3. K.J. Ayala, "The 8051 Microcontroller ", (3/e), Thomson Delmar Learning, 2004.

4. I. S. MacKenzie and R.C.W.Phan., "The 8051 Microcontroller. (4/e)", Pearson education, 2008.

Course outcomes

At the end of the course student will be able

CO1: recall and apply the basic concept of digital fundamentals to Microprocessor based personal computer system.
CO2: identify the detailed s/w & h/w structure of the Microprocessor.
CO3: illustrate how the different peripherals are interfaced with Microprocessor.
CO4: distinguish and analyze the properties of Microprocessors & Microcontrollers.
CO5: analyze the data transfer information through serial & parallel ports.

Course Code	**:**	**ECMI19**
Course Title	**:**	**DIGITAL SIGNAL PROCESSORS AND APPLICATIONS**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECMI15**
Course Type	**:**	**MI**

Course Learning Objective

- To give an exposure to the various fixed point and floating point DSP architectures, to understand the techniques to interface sensors and I/O circuits and to implement applications using these processors.

Course Content

Fixed-point DSP architectures. Basic Signal processing system. Need for DSPs. Difference between DSP and other processor architectures. TMS320C54X, ADSP21XX, DSP56XX architecture details. Addressing modes. Control and repeat operations. Interrupts. Pipeline operation. Memory Map and Buses.

Floating-point DSP architectures. TMS320C3X, DSP96XX architectures. Cache architecture. Floating-point Data formats. On-chip peripherals. Memory Map and Buses.

On-chip peripherals. Hardware details and its programming. Clock generator with PLL. Serial port. McBSP. Parallel port. DMA. EMIF. I^2C. Real-time-clock (RTC). Watchdog timer.

Interfacing. Serial interface- Audio codec. Sensors - Humidity/temperature sensor, flow sensor, accelerometer, pulse sensor and finger print scanner. A/D and D/A interfaces. Parallel interface-Memory interface. RF transceiver interface – Wi-Fi and Zigbee modules.

DSP tools and applications. Implementation of Filters, DFT, QPSK Modem, Speech processing. Video processing, Video Encoding /Decoding. Biometrics. Machine Vision. High performance computing (HPC).

Text Books

1. *B.Venkataramani & M.Bhaskar, "Digital Signal Processor, Architecture, Programming and Applications",(2/e), McGraw- Hill,2010*
2. *S.Srinivasan & Avtar Singh, "Digital Signal Processing, Implementations using DSP Microprocessors with Examples from TMS320C54X", Brooks/Cole, 2004.*

Reference Books

1. *S.M.Kuo & W.S.S.Gan," Digital Signal Processors: Architectures, Implementations, and Applications", Printice Hall, 2004*
2. *C.Marven & G.Ewers, "A Simple approach to digital signal processing", Wiley Inter science, 1996.*
3. *R.A.Haddad & T.W.Parson, "Digital Signal Processing: Theory, Applications and Hardware", Computer Science Press NY, 1991.*

Course outcomes

At the end of the course student will be able

CO1: learn the architecture details of fixed point DSPs.
CO2: learn the architecture details of floating point DSPs
CO3: infer about the control instructions, interrupts, pipeline operations, memory and buses.
CO4: illustrate the features of on-chip peripheral devices and its interfacing with real time application devices.
CO5: learn to implement the signal processing algorithms and applications in DSPs

Course Code	**:**	**ECMI20**
Course Title	**:**	**ANALOG COMMUNICATION**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECMI10**
Course Type	**:**	**MI**

Course Learning Objective

- To develop a fundamental understanding on Communication Systems with emphasis on analog modulation techniques and noise performance.

Course Content

Basic blocks of Communication System. Amplitude (Linear) Modulation – AM, DSB-SC, SSB-SC and VSB-SC. Methods of generation and detection. FDM. Super Heterodyne Receivers.

Angle (Non-Linear) Modulation - Frequency and Phase modulation. Transmission Bandwidth of FM signals, Methods of generation and detection. FM Stereo Multiplexing.

Noise - Internal and External Noise, Noise Calculation, Noise Figure. Noise in linear and nonlinear AM receivers, Threshold effect.

Noise in FM receivers, Threshold effect, Capture effect, FM Threshold reduction, Pre-emphasis and De-emphasis.

Pulse Modulation techniques – Sampling Process, PAM, PWM and PPM concepts, Methods of generation and detection. TDM. Noise performance.

Text Books

1. *S.Haykins, Communication Systems, Wiley, (4/e), Reprint 2009.*
2. *Kennedy, Davis, Electronic Communication Systems (4/e), McGraw Hill, Reprint 2008.*

Reference Books

1. *B.Carlson, Introduction to Communication Systems, McGraw-Hill, (4/e), 2009.*
2. *J.Smith, Modern Communication Circuits (2/e), McGraw Hill, 1997.*
3. *J.S.Beasley&G.M.Miler, Modern Electronic Communication (9/e), Prentice-Hall, 2008.*

Course outcomes

At the end of the course student will be able

CO1: Understand the basics of communication system and analog modulation techniques

CO2: Apply the basic knowledge of signals and systems and understand the concept of Frequency modulation.

CO3: Apply the basic knowledge of electronic circuits and understand the effect of Noise in communication system and noise performance of AM system

CO4: Understand the effect of noise performance of FM system.

CO5: Understand TDM and Pulse Modulation techniques.

Course Code	**:**	**ECMI21**
Course Title	**:**	**ANTENNAS AND PROPAGATION**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECMI12**
Course Type	**:**	**MI**

Course Learning Objective

- To impart knowledge on basics of antenna theory and to analyze and design a start of art antenna for wireless communications.

Course Content
Radiation fundamentals. Potential theory. Helmholtz integrals. Radiation from a current element. Basic antenna parameters. Radiation field of an arbitrary current distribution. Small loop antennas.

Receiving antenna. Reciprocity relations. Receiving cross section, and its relation to gain. Reception of completely polarized waves. Linear antennas. Current distribution. Radiation field of a thin dipole. Folded dipole. Feeding methods. Baluns.

Antenna arrays. Array factorization. Array parameters. Broad side and end fire arrays. Yagi-Uda arrays Log-periodic arrays.

Aperture antennas. Fields as sources of radiation. Horn antennas. Babinet's principle. Parabolic reflector antenna. Microstrip antennas.

Wave Propagation: Propagation in free space. Propagation around the earth, surface wave propagation, structure of the ionosphere, propagation of plane waves in ionized medium, Determination of critical frequency, MUF. Fading, tropospheric propagation, Super refraction.

Text Books

1. *R.E.Collin, "Antennas and Radio Wave Propagation", McGraw – Hill, 1985.*
2. *W.L.Stutzman & G.A.Thiele, "Antenna Theory and Design", Wiley.*

Reference Books

1. *K.F.Lee, "Principles of Antenna Theory", Wiley, 1984.*
2. *F.E. Terman, "Electronic Radio Engineering (4/e)", McGraw Hill.*
3. *J.R. James, P. S. Hall, and C. Wood, "Microstrip Antenna Theory and Design", IEE, 1981.*
4. *C.A.Balanis, "Modern Antenna Handbook", Wiley India Pvt. Limited, 2008.*

Course outcomes
At the end of the course student will be able

CO1: select the appropriate portion of electromagnetic theory and its application to antennas.

CO2: distinguish the receiving antennas from transmitting antennas, analyze and justify their characteristics.

CO3: assess the need for antenna arrays and mathematically analyze the types of antenna arrays.

CO4: distinguish primary from secondary antennas and analyze their characteristics by applying optics and acoustics principles.

CO5: outline the factors involved in the propagation of radio waves using practical antennas.

Course Code	**:**	**ECMI22**
Course Title	**:**	**ANALOG INTEGRATED CIRCUITS**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECMI17**
Course Type	**:**	**MI**

Course Learning Objective

- To introduce the theoretical & circuit aspects of an Op-amp.

Course Content

Operational Amplifiers, DC and AC characteristics, typical op-amp parameters: Finite gain, finite bandwidth, Offset voltages and currents, Common-mode rejection ratio, Power supply rejection ratio, Slew rate, Applications of Op-amp: Precision rectifiers. Summing amplifier, Integrators and differentiators, Log and antilog amplifiers. Instrumentation amplifiers, voltage to current converters.

Active filters: Second order filter transfer function (low pass, high pass, band pass and band reject), Butterworth, Chebyshev and Bessel filters. Switched capacitor filter. Notch filter, all pass filters, self-tuned filters

Opamp as a comparator, Schmitt trigger, Astable and monostable multivibrators, Triangular wave generator, Multivibrators using 555 timer, Data converters: A/D and D/A converters

PLL- basic block diagram and operation, four quadrant multipliers. Phase detector, VCO, Applications of PLL:Frequency synthesizers, AM detection, FM detection and FSK demodulation.

CMOS differential amplifiers**:** DC analysis and small signal analysis of differential amplifier with Restive load, current mirror load and current source load, Input common-mode range and Common-mode feedback circuits. OTAs vsOpamps. Slew rate, CMRR, PSRR. Two stage amplifiers, Compensation in amplifiers (Dominant pole compensation).

Text Books

1. *S.Franco, Design with Operational Amplifiers and Analog Integrated*
2. *Circuits (3/e) TMH, 2003.*
3. *Sedra and Smith, Microelectronics Circuits, Oxford Univ. Press, 2004*

Reference Books

1. *Coughlin, Driscoll, OP-AMPS and Linear Integrated Circuits, Prentice Hall, 2001.*

Course outcomes

At the end of the course student will be able

CO1: infer the DC and AC characteristics of operational amplifiers and its effect on output and their compensation techniques.

CO2: elucidate and design the linear and nonlinear applications of an op-amp and special application ICs.

CO3: explain and compare the working of multi vibrators using special application IC 555 and general purpose op-amp.

CO4: classify and comprehend the working principle of data converters.

CO5: illustrate the function of application specific ICs such as Voltage regulators, PLL and its application in communication.

Course Code	**:**	**ECMI23**
Course Title	**:**	**DIGITAL COMMUNICATION**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECMI20**
Course Type	**:**	**MI**

Course Learning Objectives

- To understand the key modules of digital communication systems with emphasis on digital modulation techniques.
- To get introduced to the basics of source and channel coding/decoding and Spread Spectrum Modulation.

Course Content

Base band transmission. Sampling theorem, Pulse code modulation (PCM), DM, Destination SNR in PCM systems with noise. Matched filter. Nyquist criterion for zero ISI. Optimum transmit and receive filters. Correlative Coding, M-ary PAM. Equalization- zero-forcing and basics of adaptive linear equalizers.

BASK, BFSK, and BPSK- Transmitter, Receiver, Signal space diagram, Error probabilities.

M-ary PSK, M-ary FSK, QAM, MSK and GMSK- Optimum detector, Signal constellation, error probability.

Linear block codes-Encoding and decoding. Cyclic codes – Encoder, Syndrome Calculator. Convolutional codes – encoding, Viterbi decoding. TCM.

Spread Spectrum (SS) Techniques- Direct Sequence Spread Spectrum modulation, Frequency-hop Spread Spectrum modulation - Processing gain and jamming margin.

Text Books

1. *S.Haykin, "Communication Systems", Wiley, (4/e), 2001.*
2. *J.G.Proakis, "Digital Communication", Tata McGraw – Hill, (4/e), 2001.*

Reference Books

1. *B.Sklar, "Digital Communications: Fundamentals & Applications", Pearson Education, (2/e), 2001.*
2. *A.B.Carlson, " Communication Systems", McGraw Hill, 3/e,2002*
3. *R.E.Zimer & R.L.Peterson," Introduction to Digital Communication", PHI,3/e, 2001*

Course outcomes

At the end of the course student will be able

CO1: Apply the knowledge of signals and system and explain the conventional digital communication system.
CO2: Apply the knowledge of statistical theory of communication and evaluate the performance of digital communication system in the presence of noise.
CO3: Describe and analyze the performance of advance modulation techniques.
CO4: Apply the knowledge of digital electronics and describe the error control codes like block code, cyclic code.
CO5: Describe and analyze the digital communication system with spread spectrum modulation.

Course Code	**:**	**ECMI24**
Course Title	**:**	**MICROWAVE COMPONENTS AND CIRCUITS**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECMI16**
Course Type	**:**	**MI**

Course Learning Objective

- The subject introduces the essential Microwave Circuit Theory and the design aspects of Microwave Integrated Circuit components.

Course Content

Scattering matrix formulation. Passive microwave devices; terminations, bends, corners, attenuators, phase changers, directional couplers and hybrid junctions. Basics and design considerations of Microstripline, strip line, coplanar waveguide, Slot line and Finline.

Microwave measurements; frequency, wavelength, VSWR. Impedance determination. S-parameter measurements. Network analyzer.

Microwave network parameters. Basic circuit elements for microwaves. Transmission line sections and stubs. Richard transformation. Kuroda identities.

MIC filter design. Low pass to high pass, band pass and band stop transformations. Realization using microstrip lines and strip lines.

Design and realization of MIC components.3 dB hybrid design. Ratrace Hybrid Ring, Backward wave directional coupler, power divider; realization using microstrip lines and strip lines.

Text Books

1. *I.J.Bahl & P.Bhartia, "Microwave Solid state Circuit Design", Wiley, 2003.*
2. *D.M.Pozar, "Microwave Engineering (2/e)", Wiley, 2004.*

Reference Books

1. *A. Das, "Microwave Engineering", Tata McGraw Hill, 2000*
2. *B.Bhat, S. K. Koul, "Stripline like transmission lines for Microwave Integrated Circuits", New age International Pvt. Ltd. Publishers 2007.*
3. *G. Matthaei, E.M.T. Jones , L. Young , George Matthaei, Leo Young , George L. Matthaei "Microwave filters, Impedance Matching Network, Coupling Structures (Updated)",Hardcover, 1,096 Pages, Published 1980 by Artech House Publishers ISBN-13: 978-0-89006-099-5, ISBN: 0-89006-099-1*

Course outcomes

At the end of the course student will be able

CO1: Learn the basics of S parameters and use them in describing the components
CO2: Expose to the Microwave Measurements Principle
CO3: Realize the importance of the theory of Microwave circuit theory.
CO4: Work out the complete design aspects of various M.I.C. Filters
CO5: Confidently design all M.I.C. components to meet the industry standard

Course Code	**:**	**ECMI25**
Course Title	**:**	**VLSI SYSTEMS**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECMI14**
Course Type	**:**	**MI**

Course Learning Objective

- To introduce various aspects of VLSI circuits and their design including testing**.**

Course Content

VLSI design methodology, VLSI technology- NMOS, CMOS and BICMOS circuit fabrication. Layout design rules. Stick diagram. Latch up.

Characteristics of MOS and CMOS switches. Implementation of logic circuits using MOS and CMOS technology, multiplexers and memory, MOS transistors, threshold voltage, MOS device design equations. MOS models, small-signal AC analysis. CMOS inverters, propagation delay of inverters, Pseudo NMOS, Dynamic CMOS logic circuits, power dissipation.

Programmable logic devices- anti-fuse, EPROM and SRAM techniques. Programmable logic cells. Programmable inversion and expander logic. Computation of interconnect delay, Techniques for driving large off-chip capacitors, long lines, Computation of interconnect delays in FPGAs Implementation of PLD, EPROM, EEPROM, static and dynamic RAM in CMOS.

An overview of the features of advanced FPGAs, IP cores, Softcore processors, Various factors determining the cost of a VLSI, Comparison of ASICs, FPGAs , PDSPs and CBICs . Fault tolerant VLSI architectures

VLSI testing -need for testing, manufacturing test principles, design strategies for test, chip level and system level test techniques.

Text Books

1. *N. H. E. Weste, D.F. Harris, "CMOS VLSI design", (3/e), Pearson , 2005.*
2. *J. Smith, "Application Specific Integrated Circuits, Pearson", 1997.*

Reference Books

1. *M.M.Vai, "VLSI design", CRC Press, 2001.*
2. *Pucknell & Eshraghian, "Basic VLSI Design", PHI, (3/e), 2003.*
3. *Uyemura, "Introduction to VLSI Circuits and Systems", Wiley, 2002.*

Course outcomes

At the end of the course student will be able

CO1: Describe the techniques used for VLSI fabrication, design of CMOS logic circuits, switches and memory

CO2: Describe the techniques used the design of CMOS logic circuits, switches and memory in VLSI

CO3: Generalize the design techniques and analyze the characteristics of VLSI circuits such as area, speed and power dissipation

CO4: Explain and compare the architectures for FPGA, PAL and PLDs and evaluate their characteristics such as area, power dissipation and reliability

CO4: Use the advanced FPGAs to realize Digital signal processing systems

CO5: Describe the techniques for fault tolerant VLSI circuits

Course Code	**:**	**ECMI26**
Course Title	**:**	**WIRELESS COMMUNICAITON**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECMI23**
Course Type	**:**	**MI**

Course Learning Objective

- To get an understanding of mobile radio communication principles, types and to study the recent trends adopted in cellular and wireless systems and standards**.**

Course Content

Introduction to Wireless Communication. Cellular concept. System design fundamentals. Coverage and Capacity improvement in Cellular system. Technical Challenges.

Mobile Radio Propagation; Reflection, Diffraction, Fading. Multipath propagation. Statistical characterization of multipath fading. Diversity Techniques.

Path loss prediction over hilly terrain. Practical link budget design using Path loss models. Design parameters at base station. Antenna location, spacing, heights and configurations.

Multiple access techniques; FDMA, TDMA and CDMA. Spread spectrum. Power control. WCDMA. CDMA network design. OFDM and MC-CDMA.

GSM.3G, 4G (LTE), NFC systems, WLAN technology. WLL. Hyper LAN. Ad hoc networks. Bluetooth.

Text Books:

1. *T.S.Rappaport, Wireless Communication Principles (2/e), Pearson, 2002.*
2. *A.F.Molisch, Wireless Communications, Wiley, 2005.*

Reference Books:

1. *P.MuthuChidambaraNathan, Wireless Communications, PHI, 2008.*
2. *W.C.Y.Lee, Mobile Communication Engineering. (2/e), McGraw- Hill, 1998.*
3. *A.Goldsmith, Wireless Communications, Cambridge University Press, 2005.*
4. *S.G.Glisic, Adaptive CDMA, Wiley, 2003.*

Course outcomes

At the end of the course student will be able

CO1: Apply the knowledge of basic communication systems and its principles.
CO2: Describe the cellular concept and analyze capacity improvement Techniques.
CO3: Mathematically analyze mobile radio propagation mechanisms.
CO4: Summarize diversity reception techniques.
CO5: Design Base Station (BS) parameters and analyze the antenna configurations.

Course Code	**:**	**ECMI27**
Course Title	**:**	**FIBER OPTIC COMMUNICATION**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECMI12 & ECMI20**
Course Type	**:**	**MI**

Course Learning Objective

- To expose the students to the basics of signal propagation through optical fibers, fiber impairments, components and devices and system design.

Course Content

Optical Fibers: Structure, Wave guiding. Step-index and graded index optical fibers. Modal analysis. Classification of modes. Single Mode Fibers.

Pulse dispersion. Material and waveguide dispersion. Polarization Mode Dispersion. Absorption, scattering and bending losses. Dispersion Shifted Fibers, Dispersion Compensating Fibers.

Optical Power Launching and Coupling. Lensing schemes for coupling improvement. Fiber-to-fiber joints. Splicing techniques. Optical fiber connectors.

Optical sources and detectors. Laser fundamentals. Semiconductor Laser basics. LEDs. PIN and Avalanche photodiodes, Optical TX/RX Circuits.

Design considerations of fiber optic systems: Analog and digital modulation. Noise in detection process. Bit error rate. Optical receiver operation. Power Budget and Rise time Budget. WDM.

Text Books

1. *G.Keiser, "Optical Fiber Communications (5/e)", McGraw Hill, 2013.*
2. *G.P.Agarwal, "Fiber Optic Communication Systems", (3/e), Wiley, 2002.*

Reference Books

1. *M.M.K.Liu, "Principles and Applications of Optical Communications", Tata McGraw Hill, 2010.*
2. *A.Ghatak & K.Thygarajan, "Introduction to Fiber Optics", Cambridge, 1999.*
3. *J.Gowar, "Optical Communication Systems", (2/e), PHI, 2001.*
4. *A.Selvarajan, S.Kar and T.Srinivas, "Optical Fiber Communication Principles and Systems", Tata McGraw Hill, 2002.*

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Course outcomes

At the end of the course student will be able

CO1: Recognize and classify the structures of Optical fiber and types.
CO2: Discuss the channel impairments like losses and dispersion.
CO3: Analyze various coupling losses.
CO4: Classify the Optical sources and detectors and to discuss their principle.
CO5: Familiar with Design considerations of fiber optic systems.

Course Code	**:**	**ECMI28**
Course Title	**:**	**MICROWAVE ELECTRONICS**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECMI24**
Course Type	**:**	**MI**

Course Learning Objective

- To impart knowledge on basics of microwave electron beam devices and their applications in X band frequency**.**

Course Content

Limitations of conventional vacuum tubes, Klystrons: Re-entrant cavities, Two cavity klystron, Velocity modulation process, Bunching process ,Power output and efficiency; Multi-cavity klystron , Reflex klystron-Velocity modulation process, Mode Characteristics ,Electronic admittance spiral.

Travelling-wave tubes: Slow-wave structures, Helix TWT- Amplification process, Convection current, Wave modes and gain; coupled cavity TWT, Backward wave oscillator.

Crossed -field devices: Magnetrons- Principle of operation, characteristics, Hull cut-off condition; Carcinotron, Gyrotron.

Microwave transistors and FETs: Microwave bipolar transistors-Physical structures, characteristics, Power-frequency limitations; Microwave tunnel diode, Microwave unipolar transistor – Physical structure, principle of operation, characteristics, High electron-mobility transistors.

Transferred electron and Avalanche transit-time devices: Gunn diode, Gunn diode as an oscillator. IMPATT, TRAPATT and BARITT.

Text Books

1. *S.Y.Liao, "Microwave Devices and Circuits (3/e)", PHI, 2005.*
2. *R. F. Soohoo, "Microwave Electronics", Wesley publication, 1971.*

Reference Books

1. *R.E.Collin, "Foundations for Microwave Engineering (2/e)", Wiley India, 2007.*
2. *D.M.Pozar," Microwave Engineering (3/e)", Wiley India, 2009.*
3. *K C Gupta, Indian Institute of Technology, Kanpur," Microwaves", Wiley Eastern Limited, 1995.*

Course outcomes

At the end of the course student will be able

CO1: Apply the basic knowledge of waveguide and microwave resonator circuits.
CO2: Asses the methods used for generation and amplification of the microwave power.
CO3: Distinguish between the linear and cross field electron beam microwave tubes.
CO4: Critically analyze the operating principles and performances of the microwave semiconductor devices.
CO5: Identify the suitable microwave power sources of given specification for the selected application.

Course Code	**:**	**ECLR10**
Course Title	**:**	**DEVICES AND NETWORKS LABORATORY**
Number of Credits		**2**
Corequisites (Course code)	**:**	**ECPC13**
Course Type	**:**	**ELR**

List of Experiments:

1. Study Experiment
2. PN Junction Diode Characteristics
3. Zener diode characteristics and its application
4. Characteristics study of Bipolar Junction Transistor (BJT)
5. Characteristics study of JFET
6. Response study of Series RLC
7. Constant K High pass Filter
8. Attenuators
9. Equalizers
10. Clippers and Clampers
11. SCR Characteristics
12. LAB view implementation

Course outcomes

At the end of the course student will be able

CO1: Demonstrate theoretical device/circuit operation in properly constructed analog circuits.
CO2: Able to operate standard test equipment like multi-meters, oscilloscopes, power supplies, waveform generators, and to analyze, test, and implement circuits in breadboard.
CO3: Able to analyze the operation of an active device and compare its performance with the expected performance given in the data sheets.
CO4: Able to apply troubleshooting techniques to test the circuits.
CO5: Able to analyze the circuits using the simulation tools.

Course Code	**:**	**ECLR11**
Course Title	**:**	**DIGITAL ELECTRONICS LABORATORY**
Number of Credits		**2**
Corequisites (Course code)	**:**	**ECPC14**
Course Type	**:**	**ELR**

Course Objective

- To introduce basic postulates of Boolean algebra and shows the correlation between Boolean expressions
- To introduce the methods for simplifying Boolean expressions
- To outline the formal procedures for the analysis and design of combinational circuits and sequential circuits
- To learn combinational and sequential circuit simulations using Verilog HDL.

List of Experiments:

1. Study of logic gates and verification of Boolean Laws.
2. Design of adders and subtractors & code converters.
3. Design of Multiplexers &DE multiplexers.
4. Design of Encoders and Decoders.
5. Design of Magnitude Comparators
6. Study of flip-flops.
7. Design and implementation of counters using flip-flops
8. Design and implementation of shift registers.
9. Simulation of adders, subtractors, encoders & decoders using Verilog HDL.
10. Simulation of counters & shift registers using Verilog HDL.

Course Outcomes:

Students are able to

CO1: Demonstrate theoretical device/circuit operation in properly constructed digital circuits.
CO2: Able to correctly operate standard electronic test equipment digital multi-meters, power supplies to analyze, test, and implement digital circuits.
CO3: Able to correctly analyze a circuit and compare its theoretical performance to actual performance.
CO4: Able to apply troubleshooting techniques to test digital circuits.
CO5: Able to code a given digital logic design in HDL language.

Course Code	**:**	**ECLR12**
Course Title	**:**	**ELECTRONIC CIRCUITS LABORATORY**
Number of Credits		**2**
Corequisites (Course code)	**:**	**ECPC17**
Course Type	**:**	**ELR**

List of Experiments:

Hardware Experiments

1. Stability of Q point
2. Single stage RC coupled CE amplifier
3. Single stage RC coupled Current series CE feedback amplifier
4. Darlington emitter follower
5. Differential Amplifier
6. RC phase shift oscillator
7. Colpitt's Oscillator
8. Power amplifier – Class A & class AB

Simulation Experiments

9. MOS CS amplifier with resistive load, diode connected load, current source load
10. MOS current mirrors

Course Outcomes:

Students are able to

CO1: Demonstrate theoretical device/circuit operation in properly constructed analog circuits

CO2: Able to correctly operate standard electronic test equipment digital multi-meters, power supplies to analyze, test, and implement digital circuits

CO3: Able to correctly analyze a circuit and compare its theoretical performance to actual performance

CO4: Learn different techniques employed for the enhancement of Gain and Bandwidth

CO5: Able to map the Circuits implemented to that of real time application

Course Code	**:**	**ECLR13**
Course Title	**:**	**MICROPROCESSOR AND MICROCONTROLLER LABORATORY**
Number of Credits		**2**
Corequisites (Course code)	**:**	
Course Type	**:**	**ELR**

Course Objective

- This course deals with several languages used for programming a Microprocessors and Microcontrollers through industry-standard compilers, Macro Assemblers, Debuggers, Real-time Kernels, and system-level simulators. Using the hardware kits to get the hands-on experience on 16-bit Microprocessor, 8-bit and 16-bit Microcontrollers and also interfacing the different peripherals.

List of Experiments:

Intel 8086 – 16bit µP- Emulator.

1. Addressing modes of 8086 Microprocessor.
2. Block move and simple arithmetic operations.
3. Identification and displaying the activated key using DOS and BIOS function calls.

Intel 8051 (8-bit Microcontroller) - Proteus VSM Simulator and Trainer Kit.

4. Addressing modes of 8051 Microcontroller.
5. Delay generation - i) Nested loop and ii) Timers.
6. Toggling the ports and counting the pulses.
7. LCD Interfacing.
8. Generation of different waveforms using DAC (0808)
9. ADC interfacing.

Mixed-Signal Microcontroller – 16bit – MSP430 series

10.PWM generation and speed control of Motors using MSP430.

Course Outcomes:

After successful completion of the course, the students are able to

CO1: train their practical knowledge through laboratory experiments.
CO2: understand and write the assembly language programs to control the systems.
CO3: learn system-level simulator and design complete Microcontroller based modules.
CO4: study Code Composer Studio to develop and debug embedded applications.
CO5: do projects in IoT applications.

Course Code	**:**	**ECLR14**
Course Title	**:**	**ANALOG VLSI & EMBEDDED SYSTEM LABORATORY**
Number of Credits		**2**
Corequisites (Course code)	**:**	**ECPC21& ECPC23**
Course Type	**:**	**ELR**

List of Experiments:

1. Study the characteristics of negative feedback amplifier
2. Design of an instrumentation amplifier
3. Study the characteristics of regenerative feedback system-Schmitt trigger
4. Design of a second order Butterworth band-pass filter for the given higher and lower cut-off frequencies
5. Design of a function generator-Square, Triangular wave

List of Experiments: USING XILINX

1. Comparators, parity generators & ALU
2. Flip-Flops, Shift-Registers & Counters Using Cadence
1. Dc transfer characteristics of an Inverter
2. Design, Simulation and Layout of basic digital blocks
3. Mini Project on VLSI Design

Course Outcomes:

After successful completion of the course, the students are able to

1. Study the characteristics of negative feedback amplifier.
2. Design of an instrumentation amplifier.
3. Study the characteristics of regenerative feedback system- Schmitt trigger.
4. Design of a second order Butterworth band-pass filter for the given higher and lower cut-off frequencies.
5. Design of a function generator- DSquare, Triangular wave.
6. To study, design and experimentally verify Comparators, Parity Generators and ALU using XILINX.
7. Design of Flip-Flops, Shift-Registers & Counters Using XILINX.
8. Design and to study the DC transfer characteristics of an Inverter using Cadence.
9. Able to apply troubleshooting techniques to design, layout, simulate and test the digital circuits as blocks.
10. Able to map the Circuits implemented to that of real time application.

Course Code	**:**	**ECLR15**
Course Title	**:**	**DIGITAL SIGNAL PROCESSING LABORATORY**
Number of Credits		**2**
Corequisites (Course code)	**:**	**ECPC15**
Course Type	**:**	**ELR**

Course Objective:

1. To program and analyse the signal processing functions such as convolution, correlation etc. using Matlab tool.
2. To learn and implement algorithms for FIR, IIR filters and DFT using FFT using Matlab tool.
3. To learn the addressing modes and implement the DSP algorithms in digital signal processors.

Course Content:

List of Experiments:

MATLAB tool based simulation experiments

1. Realization of correlation of two discrete signals
2. Realization of convolution
3. FIR filter design
4. IIR filter design
5. DFT implementation
6. SNR and Power spectral density estimation of signals

TMS320C5416 Digital Signal Processor kit based Experiments

1. Study of various addressing modes and arithmetic sequence generation
2. Convolution using MAC, MACD and MACP instructions. Convolution using overlap add and overlap save method
3. Wave pattern generation
4. FIR filter implementation
5. DFT implementation using FFT radix-2 algorithm
6. Serial interface and data acquisition

Course Outcomes:

At the end of the course student will be able

CO1: To write Matlab program for signal processing functions
CO2: To implement algorithms to realize digital filters and transforms
CO3: To write and execute application program in digital signal processors
CO4: To implement signal processing algorithms in digital signal processors
CO5: To learn real time interfacing and data acquisition of signals

Course Code	**:**	**ECLR16**
Course Title	**:**	**COMMUNICATION ENGINEERING LABORATORY**
Number of Credits		**2**
Corequisites (Course code)	**:**	**ECPC18 & ECPC19**
Course Type	**:**	**ELR**

List of Experiments:

1. AM Modulation and Demodulation
2. DSB-SC Modulation
3. Pulse Amplitude Modulation and Demodulation
4. Pulse Width Modulation and Demodulation
5. Pulse Position Modulation using PLL(IC 565)
6. Amplitude Shift Keying (ASK) Modulation and Demodulation
7. Frequency Shift Keying (FSK) Modulation and Demodulation
8. Frequency Multiplier using PLL
9. Analog and digital modulation using COMMSIM simulation tool
10. Analog and digital modulation using MATLAB
11. Sample and Hold Circuit
12. Study of wireless communication system using Wi-Comm Kit

Course Outcomes:

At the end of the course student will be able

CO1: To design and analyse the analog modulation and demodulation circuits
CO2: To carry out analog pulse modulation and demodulation
CO3: To design and perform digital modulation and demodulation
CO4: To perform frequency multiplication using PLL
CO5: To perform modulation using simulation tool and to get exposed to WiComm Kit.

Course Code	**:**	**ECLR17**
Course Title	**:**	**MICROWAVE &FIBER OPTIC LABORATORY**
Number of Credits		**2**
Co-requisites (Course code)	**:**	**ECPC24**
Course Type	**:**	**ELR**

List of Experiments:

Microwave Experiments

1. Study the characteristics of microwave sources (Gunn Diode, Reflex Klystron)
2. Impedance Measurement of unknown devices.
3. Study the characteristics of Reciprocal devices (Directional Coupler, E-Plane Tee , H- Plane Tee etc.,)
4. Study the characteristics of Non Reciprocal devices (Isolator, Circulator)
5. Study the Characteristics of horn Antenna.
6. Microwave CAD -Design and analysis of Planar Antenna

Fiber Optic Communication Experiments

1. Characteristics of Optical Sources - Laser Diode and LED
2. Characteristics of Photodetectors - PIN Photodetector and Avalanche Photodiode (APD)
3. Characteristics of Optical Fiber-Measurement of Numerical Aperture, Attenuation, Bending Loss and Fiber Dispersion
4. Analog and Voice Communication through Optical Link
5. Performance Measurement in Optical System-BER and Q-factor Estimation, Optical Receiver Sensitivity Characteristics
6. Photonics CAD - WDM Link

COURSE OUTCOME:
At the end of course student will be able to

CO1: Understand the characteristics of optical sources and photodetectors in the fiber optic communication systems.
CO2: Understand the characteristics and various propagation effects of the optical fibers.
CO3: Construct analog and voice communication through optical fibers.
CO4: Analyze the performance parameters of the fiber optic communication systems through simulation software.
CO5: Interpret the operating principle of wavelength division multiplexing systems.

Course Code	**:**	**ECHO11**
Course Title	**:**	**SPECTRAL ANALYSIS OF SIGNALS**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECPC15**
Course Type	**:**	**HO**

Course learning Objective

- To give an exhaustive survey of methods available for power spectrum estimation.

Course content

Periodogram and correlogram. Blackman – Tukey, Bartlett, Welch and Daniel methods. Window design considerations.

Parametric methods for rational spectra. Covariance structure of ARMA processes. AR, MA and ARMA signals. Multivariate ARMA signals.

Parametric methods for line spectra. Models of sinusoidal signals in noise. Nonlinear least squares, high order Yule-Walker, min-norm, Pisarenko, MUSIC and ESPRIT methods.

Filter bank methods. Filter-bank interpretation of the periodogram. Refined filter-bank and Capon methods.

Spatial methods. Array model. Nonparametric methods; beam forming and Capon method. Parametric methods; nonlinear least squares, Yule-Walker, min-norm, Pisarenko, MUSIC and ESPRIT methods.

Text Books

1. *P.Stoica & R.Moses, "Spectral Analysis of signals", Pearson, 2005.*
2. *Marple, "Introduction to Spectral Analysis", Prentice Hall.*

Reference Books

1. *S.M.Key, "Fundamentals of Statistical Signal Processing", Prentice Hall PTR, 1998.*
2. *Recent literature in Spectral Analysis of Signals.*

Course outcomes

At the end of the course student will be able

CO1: derive and analyse the statistical properties of the conventional spectral estimators, namely the periodogram, averaged & modified periodogram and Blackman-Tukey methods.

CO2: formulate modern, parametric, spectral estimators based upon autoregressive (AR), moving average (MA), and autoregresive moving average (ARMA) models, and detail their statistical properties. Describe the consequence of the term resolution as applied to a spectral estimator.

CO3: define techniques for calculating moments in spectral and temporal domains; Analyze filter bank method, capon methods for spectrum estimation.

CO4: demonstrate knowledge and understanding of the principles of parametric and non-parametric array processing algorithms.

CO5: select an appropriate array processing algorithms for frequency estimation and sonar, radar applications.

Course Code	**:**	**ECHO12**
Course Title	**:**	**DETECTION AND ESTIMATION**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**MAIR 45**
Course Type	**:**	**HO**

Course learning Objective

- The objective of this course is to make the students conversant with those aspects of statistical decision and estimation which are indispensable tools required for the optimal design of digital communication systems.

Course content

Binary hypothesis testing; Bayes, minimax and Neyman-Pearson tests. Composite hypothesis testing.

Signal detection in discrete time: Models and detector structures. Coherent detection in independent noise. Detection in Gaussian noise. Detection of signals with random parameters. Detection of stochastic signals. Performance evaluation of signal detection procedures.

Bayesian parameter estimation; MMSE, MMAE and MAP estimates. Nonrandom parameter estimation. Exponential families. Completeness theorem. ML estimation. Information inequality. Asymptotic properties of MLEs.

Discrete time Kalman- Bucy filter. Linear estimation. Orthogonality principle. Wiener- Kolmogorov filtering – causal and non-causal filters.

Signal detection in continuous time: Detection of deterministic signals in Gaussian noise. Coherent detection in white Gaussian noise.

TextBooks

1. *H.V.Poor, "An Introduction to Signal Detection and Estimation (2/e) Springer", 1994.*
2. *B.C.Levy, "Principles of Signal Detection and Parameter Estimation", Springer, 2008.*

ReferenceBooks

1. *H.L.Vantrees, "Detection, Estimation and Modulation theory", Part I, Wiley, 1987.*
2. *M.D.Srinath & P.K.Rajasekaran, "Statistical Signal Processing with Applications", Wiley, 1979.*
3. *J.C.Hancock & P.A. Wintz, "Signal Detection Theory", Mc-Graw Hill, 1966.*
4. *Recent literature in Detection and Estimation.*

Course outcomes

At the end of the course student will be able

CO1: summarize the fundamental concept on Statistical Decision Theory and Hypothesis Testing

CO2: summarize the various signal estimation techniques with additive noise

CO3: summarizer with Bayesian parameter estimation (minimum mean square error (MMSE), minimum mean absolute error (MMAE), maximum a-posterior probability (MAP) estimation methods).

CO4: compare optimal filtering, linear estimation, and Wiener/Kalman filtering.

CO5: construct Wiener and Kalman filters (time discrete) and state space models.

Course Code	**:**	**ECHO13**
Course Title	**:**	**WAVELET SIGNAL PROCESSING**
Number of Credits		**4**
Prerequisites (Course code)	**:**	**ECPC15**
Course Type	**:**	**HO**

Course learning Objective

- To expose the students to the basics of wavelet theory and to illustrate the use of wavelet processing for data compression and noise suppression.

Course content

Limitations of standard Fourier analysis. Windowed Fourier transform. Continuous wavelet transform. Time-frequency resolution.

Multiresolution analysis and properties. The Haar wavelet, Structure of subspaces in MRA

Haar decomposition-1, Haar decomposition-2, Wavelet reconstruction, Haar wavelet and link to filter bank, demo on wavelet decomposition, Wavelet packets

Wavelet methods for signal processing. Noise suppression. Representation of noise-corrupted signals using frames. Algorithm for reconstruction from corrupted frame representation.

Wavelet methods for image processing. Burt- Adelson and Mallat's pyramidal decomposition schemes. 2D-dyadic wavelet transform.

Text Books

1. *E.Hernandez & G.Weiss, A First Course on Wavelets, CRC Press, 1996.*
2. *L.Prasad & S.S.Iyengar, Wavelet Analysis with Applications to Image Processing, CRC Press, 1997.*

Reference Books

1. *A.Teolis, Computational Signal Processing with Wavelets, Birkhauser, 1998*
2. *R.M. Rao & A.S. Bopardikar, Wavelet Transforms, Addition Wesley, 1998.*
3. *J.C. Goswami & A.K. Chan, Fundamentals of Wavelets, John Wiley, 1999.*
4. *Recent literature in Wavelet Signal Processing*.

Course outcomes

At the end of the course student will be able

CO1: understand about windowed Fourier transform and difference between windowed Fourier transform and wavelet transform.
CO2: understand wavelet basis and characterize continuous and discrete wavelet transforms
CO3: understand multi resolution analysis and identify various wavelets and evaluate their time-frequency resolution properties
CO4: implement discrete wavelet transforms in signal processing applications
CO5: understand about wavelet methods in image processing

Course Code	**:**	**ECHO14**
Course Title	**:**	**RF CIRCUITS**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**HO**

Course learning Objective

- To impart knowledge on basics of IC design at RF frequencies.

Course content

Characteristics of passive IC components at RF frequencies – interconnects, resistors, capacitors, inductors and transformers – Transmission lines. Noise – classical two-port noise theory, noise models for active and passive components High frequency amplifier design – zeros as bandwidth enhancers, shunt-series amplifier, fdoublers ,neutralization and uni-lateralization

Low noise amplifier design – LNA topologies, power constrained noise optimization, linearity and large signal performance

Mixers – multiplier-based mixers, subsampling mixers, diode-ring mixers

RF power amplifiers – Class A, AB, B, C, D, E and F amplifiers, modulation of power amplifiers, linearity considerations

Oscillators & synthesizers – describing functions, resonators, negative resistance oscillators, synthesis with static moduli, synthesis with dithering moduli, combination synthesizers – phase noise considerations.

Text Books

1. *T.homas H. Lee, "The Design of CMOS Radio-Frequency Integrated Circuits", 2nd ed., Cambridge, UK: Cambridge University Press,2004.*
2. *B.Razavi, "RF Microelectronics", 2nd Ed., Prentice Hall, 1998.*

Reference Books

1. *A.A. Abidi, P.R. Gray, and R.G. Meyer, eds., "Integrated Circuits for Wireless Communications", New York: IEEE Press,1999.*
2. *R. Ludwig and P. Bretchko, "RF Circuit Design, Theory and Applications", Pearson,2000.*
3. *Mattuck,A., "Introduction to Analysis",Prentice-Hall,1998.*
4. *Recent literature in RF Circuits.*

Course outcomes

At the end of the course student will be able

CO1: Understand the Noise models for passive components and noise theory
CO2: Analyze the design of a high frequency amplifier
CO3: Appreciate the different LNA topologies & design techniques
CO4: Distinguish between different types of mixers
CO5: Analyse the various types of synthesizers, oscillators and their characteristics.

Course Code	**:**	**ECHO15**
Course Title	**:**	**NUMERICAL TECHNIQUES FOR MIC**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECPC25**
Course Type	**:**	**HO**

Course learning Objective

- This subject will prepare the student to face the challenging problem of the most important component of Research namely the numerical analysis.

Course content

Over view of Numerical Techniques for Microwave integrated Circuits: Introduction, Quasi Static and Full wave Analysis, Outline if Finite element method, Integral Equation Technique, Planar Circuit Analysis, Spectral Domain Approach, The Method of Lines, The Mode Matching Method, The Transverse Resonance Technique

The Finite Element Method: Introduction, The Method of Weighted Residuals, The Variational Method Using a Variational Expression, The Finite Element Method, Integral Formulation of Problems, Antennas and Scattering from Conductors ,Waveguides-Hollow, Dielectric and Optical Finite Difference in space and Time Matrix Computations. A Finite Element Computer Program for Micro strips

Planar Circuit Analysis: Introduction, Planar Circuit Analysis' Function Approach Impedance Green's Functions Contour Integral Approach Analysis of Planar Components of Composite Configurations Planar Circuits with Anisotropic Spacing Media Applications of the Planar Circuits Concept Summary

Spectral Domain Approach: Introduction, General Approach for Shielded Microstrip Lines, the Admittance Approach Formulations for Slot lines, Fin lines, and Coplanar Waveguides Numerical Computation

Transverse Resonance Technique: Introduction, Inhomogeneous Waveguides Uniform along a Traverse Coordinate, Conventional Traverse Resonance Technique for Transversely Discontinuous Waveguides, Generalized Transverse Resonance Technique for Transversely Discontinuous Inhomogeneous Analysis of Discontinuities and Junctions by the Generalized Transverse Resonance Technique, Examples of Computer Programs.

Text Book

1. *T.Itoh, Numerical Techniques for Microwave Integrated Circuits., John Wiley and sons,1989.*
2. Cam Nguyen,Analysis Methods FOR RF,Microwave AND Millimeter_wave Planar Transmission Line Structures, John Wiley & Sons, INC.2000.

Reference Books

1. Bharathi Bhat, Shiban K.Koul, Analysis, Design and Applications of Fin lines. Artech House. 1987.
2.*Recent literature in numerical techniques for microwave integrated circuits.*

Course outcomes

At the end of the course student will be able
CO1: bring awareness of the need for numerical analysis of M.I.C. And prepare to formulate all popular numerical techniques of M.I.C.
CO2: make one formulate and write coding for Finite Element Method
CO3: prepare a person to be strong in the planar circuit Analysis
CO4: bring awareness of the most popular quasi state analysis Spectral Domain Techniques
CO5: prepare the student formulate and write coding for the Transverse Resonance Techniques

Course Code	**:**	**ECHO16**
Course Title	**:**	**APPLIED PHOTONICS**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**HO**

Course learning Objectives

- To prepare the students understand the fundamental principles of light-matter interaction and photonic band gap structures.
- To enable the students appreciate the diverse applications of fiberopticsensors.

Course content

Introduction to photonics; optical waveguide theory; Interference of light waves -numerical techniques and simulation

Photonic waveguide components Optical Modulators and Switches Electro-optics - Acousto-optics - Magneto-optics

Photonic Band gap Structures: Concept of photonic crystal; band gap and band structures in 1D, 2D and 3D photonic crystal structures;

Photo-refractive materials, non-linear optics, recent trends in bio and nano-photonics

Optical fiber sensors - Sensing using optical fibers - Types:-Amplitude, Inter-ferometric, Wavelength, Polarimetric – Distributed Sensors

Text Books

1. *A. Ghatak and K. Thyagarajan, "Introduction to Fiber Optics", Cambridge University Press,2006.*
2. *PochiYeh and AmnonYariv Photonics," Optical Electronics in Modern Communications",2007*

Reference Books

1. *F. T. S. Yu and S.Yin, "Fiber Optic Sensors", Marcel Dekker, Inc2002*
2. *G. W. Hanson, "Fundamentals of Nanoelectronics ",Pearson Education, 1st edition,2008*
3. *B. Saleh and M. Teich, "Fundamentals of Photonics", Wiley & Sons, 2007*
4. *Recent literature in Applied Photonics.*

Course outcomes

At the end of the course student will be able

CO1: understand the interference of light and optical waveguide theory.
CO2: understand the significance of photonic band gap structures and their application
CO3: analyze the different types of optical modulators.
CO4: compare the merits and demerits of different types of fiber optic sensors.
CO5: understand the application of nonlinear optics in bio and nano-photonics.

Course Code	**:**	**ECHO17**
Course Title	**:**	**ADVANCED RADIATION SYSTEMS**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECPC19**
Course Type	**:**	**HO**

Course learning Objectives

- To prepare the students understand the operating principles of various RF radiating systems.
- To enable the students appreciate the diverse applications of radiating systems.
- To design the suitable antenna systems to serve a defined application.

Course content

Antenna Fundamentals

Antenna fundamental parameters, Radiation integrals, Radiation from surface and line current distributions – dipole, monopole, loop antenna; Broadband antennas and matching techniques, Balance to unbalance transformer, Introduction to numerical techniques.

Apertures Antennas

Field equivalence principle, Radiation from Rectangular and Circular apertures, Uniform aperture distribution on an infinite ground plane; Slot antenna; Horn antenna; Reflector antenna, aperture blockage, and design consideration.

Arrays

General structure of phased array, linear array theory, variation of gain as a function of pointing direction, frequency scanned arrays, digital beam forming, and MEMS technology in phased arrays-Retro directive and self-phased arrays.

Micro Strip Antenna

Radiation Mechanism from patch; Excitation techniques; Microstrip dipole; Rectangular patch, Circular patch, and Ring antenna – radiation analysis from transmission line model, cavity model; input impedance of rectangular and circular patch antenna; Application of microstrip array antenna.

Terahertz Planar Antennas

Electronics band gap materials - Photonic Band-gap Structures- Tera Hertz Patch antennas-Special antenna structures.

Text Books

1. *S. Haykins," Communication Systems", John Wiley, 3$^{rd.}$Edition,1995.*
2. *RR Gulathi, "Monochrome and Colour Television", New Age International Publishers, 2ndedition, 2005.*

Reference Book

1. *J. G. Proakis& M .Salehi," Communication Systems Engineering", Prentice Hall, 2ndedition, 2002.*
3. *Kennedy & Davis," Electronic Communication systems", Tata McGraw Hill, 4thedition, 1999.*
4. *Recent literature in Advanced Radiation Systems.*

Course outcomes

At the end of the course student will be able

CO1: understand the various antenna parameters and different impedance matching techniques.
CO2: understand the working principle of apertures antennas.
CO3: analyze how the electronic beam formation is done using array of antennas.
CO4: compare the merits and demerits of various microwave patch antenna structures.
CO5: understand the photonic band gap structures and its application in tera hertz antennas.

Course Code	**:**	**ECHO18**
Course Title	**:**	**BIO MEMS**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**HO**

Course learning Objective

- To train the students in the design aspects of Bio MEMS devices and Systems. To make the students aware of applications in various medical specialists especially the Comparison of conventions methods and Bio MEMS usage.

Course content

Introduction-The driving force behind Biomedical Applications-Biocompatibility-Reliability Considerations-Regularity Considerations-Organizations-Education of Bio MEMS-Silicon Micro fabrication-Soft Fabrication techniques

Micro fluidic Principles- Introduction-Transport Processes- Electro kinetic Phenomena-Micro valves –Micro mixers- Micro-pumps.

SENSOR PRINCIPLES and MICRO SENSORS: Introduction-Fabrication-Basic Sensors-Optical fibers- Piezo electricity and SAW devices-Electrochemical detection-Applications in Medicine

MICRO ACTUATORS and DRUG DELIVERY: Introduction-Activation Methods-Micro actuators for Micro fluidics-equivalent circuit representation-Drug Delivery

MICRO TOTAL ANALYSIS: Lab on Chip-Capillary Electrophoresis Arrays-cell, molecule and Particle Handling-Surface Modification-Microsphere-Cell based Bioassay Systems

Detection and Measurement Methods-Emerging Bio MEMS Technology-Packaging, Power, Data and RF Safety-Biocompatibility, Standards

Text Book

1. *S.S. Saliterman," Fundamentals of Bio MEMS and Medical Micro devices", Wiley Interscience, 2006.*

Reference Books

1. *A. Folch ,"Introduction to Bio MEMS", CRC Press,2012*
2. *G.A. Urban, "Bio MEMS", Springer,2006*
3. *W. wang, S.A. Soper," Bio MEMS", 2006.*
4. *M. J. Madou, "Fundamental of Micro fabrication",*2002.
5. *G.T. A. Kovacs, "Micro machined Transducers Source book", 1998***.**
6. *Recent literature in Bio MEMS.*

Course outcomes

At the end of the course student will be able

CO1: learn and realize the MEMS applications in Bio Medical Engineering
CO2: understand the Micro fluidic Principles and study its applications.
CO3: learn the applications of Sensors in Health Engineering.
CO4: learn the principles of Micro Actuators and Drug Delivery system
CO5: learn the principles and applications of Micro Total Analysis

Course Code	**:**	**ECHO19**
Course Title	**:**	**ANALOG IC DESIGN**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECPC20**
Course Type	**:**	**HO**

Course learning Objectives

- To develop the ability design and analyze MOS based Analog VLSI circuits to draw the equivalent circuits of MOS based Analog VLSI and analyse their performance.
- To develop the skills to design analog VLSI circuits for a given specification.

Course content

Basic MOS Device Physics – General Considerations, MOS I/V Characteristics, Second Order effects, MOS Device models. Short Channel Effects and Device Models. Single Stage Amplifiers – Basic Concepts, Common Source Stage, Source Follower, Common Gate Stage, Cascode Stage.

Differential Amplifiers – Single Ended and Differential Operation, Basic Differential Pair, Common-Mode Response, Differential Pair with MOS loads, Gilbert Cell. Passive and Active Current Mirrors – Basic Current Mirrors, Cascode Current Mirrors, Active Current Mirrors.

Frequency Response of Amplifiers – General Considerations, Common Source Stage, Source Followers, Common Gate Stage, Cascode Stage, Differential Pair. Noise – Types of Noise, Representation of Noise in circuits, Noise in single stage amplifiers, Noise in Differential Pairs.

Feedback Amplifiers – General Considerations, Feedback Topologies, Effect of Loading. Operational Amplifiers – General Considerations, One Stage Op Amps, Two Stage Op Amps, Gain Boosting, Common-Mode Feedback, Input Range limitations, Slew Rate, Power Supply Rejection, Noise in Op Amps. Stability and Frequency Compensation.

Band gap References, Introduction to Switched Capacitor Circuits, Nonlinearity and Mismatch.

Text Books

1. *B.Razavi, "Design of Analog CMOS Integrated Circuits", McGraw Hill Edition2002.*
2. *Paul. R.Gray, Robert G. Meyer, "Analysis and Design of Analog Integrated Circuits", Wiley, (4/e), 2001.*

Reference Books

1. *D. A. Johns and K. Martin, "Analog Integrated Circuit Design", Wiley,1997.*
2. *R. Jacob Baker, "CMOS Circuit Design, Layout, and Simulation", Wiley, (3/e),2010.*
3. *P.E.Allen, D.R. Holberg, "CMOS Analog Circuit Design", Oxford University Press,2002.*
4. *Recent literature in Analog IC Design.*

Course outcomes

At the end of the course student will be able

CO1: draw the equivalent circuits of MOS based Analog VLSI and analyze their performance.
CO2: design analog VLSI circuits for a givenspecification.
CO3: Analyse the frequency response of the different configurations of a amplifier.
CO4: Understand the feedback topologies involved in the amplifierdesign.
CO5: Appreciate the design features of the differentialamplifiers.

Course Code	**:**	**ECHO20**
Course Title	**:**	**VLSI SYSTEM TESTING**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECPE31**
Course Type	**:**	**HO**

Course learning Objective

- To expose the students, the basics of testing techniques for VLSI circuits and Test Economics.

Course content

Basics of Testing: Fault models, Combinational logic and fault simulation, Test generation for Combinational Circuits. Current sensing based testing. Classification of sequential ATPG methods. Fault collapsing and simulation

Universal test sets: Pseudo-exhaustive and iterative logic array testing. Clocking schemes for delay fault testing. Testability classifications for path delay faults. Test generation and fault simulation for path and gate delay faults.

CMOS testing: Testing of static and dynamic circuits. Fault diagnosis: Fault models for diagnosis, Cause- effect diagnosis, Effect-cause diagnosis.

Design for testability: Scan design, Partial scan, use of scan chains, boundary scan, DFT for other test objectives, Memory Testing.

Built-in self-test: Pattern Generators, Estimation of test length, Test points to improve testability, Analysis of aliasing in linear compression, BIST methodologies, BIST for delay fault testing.

Text Books

1. *N. Jha& S.D. Gupta, "Testing of Digital Systems", Cambridge,2003.*
2. *W. W. Wen, "VLSI Test Principles and Architectures Design for Testability", Morgan Kaufmann Publishers.2006*

Reference Books

1. *Michael L. Bushnell &Vishwani D. Agrawal," Essentials of Electronic Testing for Digital, memory & Mixed signal VLSI Circuits", Kluwar Academic Publishers.2000.*
2. *P. K. Lala," Digital circuit Testing and Testability", Academic Press.1997.*
3. *M. Abramovici, M. A. Breuer, and A.D. Friedman, "Digital System Testing and Testable Design", Computer Science Press,1990.*
4. *Recent literature in VLSI System Testing.*

Course outcomes

At the end of the course student will be able

CO1: apply the concepts in testing which can help them design a better yield in IC design.
CO2: tackle the problems associated with testing of semiconductor circuits at earlier design levels so as to significantly reduce the testing costs.
CO3: analyze the various test generation methods for static & dynamic CMOS circuits.
CO4: identify the design for testability methods for combinational & sequential CMOS circuits.
CO5: recognize the BIST techniques for improving testability.

Course Code	**:**	**ECHO22**
Course Title	**:**	**DESIGN OF ASICS**
Number of Credits		**(3-1-0) 4**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**HO**

Course learning Objectives

- To prepare the student to be an entry-level industrial standard ASIC or FPGA designer.
- To give the student an understanding of issues and tools related to ASIC/FPGA design and implementation.
- To give the student an understanding of basics of System on Chip and Platform based design.
- To give the student an understanding of High performance algorithms

Course content

Introduction to Technology, Types of ASICs, VLSI Design flow, Economics of ASICs, ASIC Cell Libraries, Design and Layout Rules, Programmable ASICs - Antifuse, SRAM, EPROM, EEPROM based ASICs. Programmable ASIC logic cells and I/O cells - Actel, Altera, Xilinx. Programmable interconnects - Actel, Altera, Xilinx. Advanced FPGAs and CPLDs and Soft-core processors. Self-Study: Multi-core processors, High performance computing (HPC), Cache, High speed memories (DDR4), High speed serdes (56Gbps, PAM4), GPU

ASIC physical design issues, System Partitioning, Estimating ASIC Size, FPGA Partitioning, Floorplanning and Placement. Algorithms: K-L, FM, Look-ahead, Simulated annealing algorithms. Full Custom Design: Basics, Needs & Applications. Schematic and layout basics, Full Custom Design Flow.

Semicustom Approach: Synthesis (RTL to GATE netlist) - Introduction to Constraints (SDC), Introduction to Static Timing Analysis (STA). Place and Route (Logical to Physical Implementation): Floorplan and Power-Plan, Placement, Clock Tree Synthesis (clock planning), Routing, Timing Optimization, GDS generation.

Overview of Extraction, Logical equivalence and STA: Parasitic Extraction Flow, STA: Timing Flow, LEC. Introduction to Physical Verification flow and Tools used: Introduction, DRC, LVS and basics of DFM. High performance algorithms for FPGA & ASICs – Multipliers - Serial and Parallel approaches, Canonic Signed Digit Arithmetic, KCM, Distributed Arithmetic, High performance digital filters for sigma-delta ADC.

System-On-Chip Design - SoC Design Flow, Platform-based and IP based SoC Designs, Basic Concepts of Bus-Based Communication Architectures, Bus Data transfer modes. On-chip bus architectures, Socket based on-chip bus interface standards. Case study: FSM design, clock domain crossing, FIFOs. Core (ARM) and IOs (I2C, PWM, GPIO, SPI, NAND, Ethernet, USB, High speed serdes etc. are interconnected through AXI/APB buses (protocols and interconnects)

Text Books

1. *M.J.S. Smith : Application Specific Integrated Circuits, Pearson, 2003*
2. *Sudeep Pasricha and NikilDutt, On-Chip Communication Architectures System on Chip Interconnect, Elsevier, 2008*

Reference Books

1. *H.Gerez, Algorithms for VLSI Design Automation, John Wiley, 1999*
2. *Jan.M.Rabaey et al, Digital Integrated Circuit Design Perspective (2/e), PHI 2003*
3. *David A.Hodges, Analysis and Design of Digital Integrated Circuits (3/e), MGH 2004*
4. *Hoi-Jun Yoo, Kangmin Leeand Jun Kyong Kim, Low-Power NoC for High-Performance SoC Design, CRC Press, 2008*
5. *An Integrated Formal Verification solution DSM sign-off market trends, www.cadence.com.*

Course outcomes

At the end of the course student will be able

CO1: demonstrate VLSI tool-flow and appreciate FPGA and CPLD architectures

CO2: understand the issues involved in ASIC design. Understand Full Custom Design Flow and Tool used.

CO3: understand Semicustom Design Flow and Tool used - from RTL to GDS and Logical to Physical Implementation.

CO4: understand about STA, LEC, DRC, LVS, DFM.

CO5: understand the System on Chip Design and On-chip communication architectures with case studies.

Course Code	**:**	**ECHO23**
Course Title	**:**	**DIGITAL SYSTEM DESIGN**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECPC14**
Course Type	**:**	**HO**

Course learning Objective

- To get an idea about designing complex, high speed digital systems and how to implement such design.

Course content

Mapping algorithms into Architectures: Datapath synthesis, control structures, critical path and worst case timing analysis. FSM and Hazards.

Combinational network delay. Power and energy optimization in combinational logic circuit. Sequential machine design styles. Rules for clocking. Performance analysis.

Sequencing static circuits. Circuit design of latches and flip-flops. Static sequencing element methodology. Sequencing dynamic circuits. Synchronizers.

Data path and array subsystems: Addition / Subtraction, Comparators, counters, coding, multiplication and division. SRAM, DRAM, ROM, serial access memory, context addressable memory.

Reconfigurable Computing**-** Fine grain and Coarse grain architectures, Configuration architectures-Single context, Multi context, partially reconfigurable, Pipeline reconfigurable, Block Configurable, Parallel processing.

Text Books

1. *N.H.E.Weste, D. Harris, CMOS VLSI Design (3/e), Pearson,2005.*
2. *W.Wolf, FPGA- based System Design, Pearson,2004.*

Reference Books

1. *S. Hauck, A.DeHon, "Reconfigurable computing: the theory and practice of FPGA-based computation", Elsevier, 2008.*
2. *Franklin P. Prosser, David E. Winkel, Art of Digital Design, Prentice-Hall,1987.*
3. *R.F.Tinde," Engineering Digital Design", (2/e), Academic Press,2000.*
4. *C. Bobda, "Introduction to reconfigurable computing", Springer, 2007.*
5. *M. Gokhale, "Paul S. Graham, Reconfigurable computing: accelerating computation with field- programmable gate arrays", Springer,2005.*
6. *C.Roth, "Fundamentals of Digital Logic Design", Jaico Publishers, V ed.,2009.*
7. *Recent literature in Digital System Design.*

Course outcomes

At the end of the course student will be able

CO1: identify mapping algorithms into architectures.
CO2: summarize various delays in combinational circuit and its optimization methods.
CO3: summarize circuit design of latches and flip-flops.
CO4: construct combinational and sequential circuits of medium complexity that is based on VLSIs, and programmable logic devices.
CO5: summarize the advanced topics such as reconfigurable computing, partially reconfigurable, Pipeline reconfigurable architectures and block configurable.

Course Code	**:**	**ECHO24**
Course Title	**:**	**OPTIMIZATIONS OF DIGITAL SIGNAL PROCESSING STRUCTURES FOR VLSI**
Number of Credits		**(3-1-0) 4**
Prerequisites (Course code)	**:**	**ECPC20**
Course Type	**:**	**HO**

Course learning Objectives

- To understand the various VLSI architectures for digital signal processing.
- To know the techniques of critical path and algorithmic strength reduction in the filter structures.
- To enable students to design VLSI system with high speed and low power.
- To encourage students to develop a working knowledge of the central ideas of implementation of DSP algorithm with optimized hardware.

Course content

An overview of DSP concepts, Typical DSP Algorithms, DSP Applications Demands and Scaled CMOS Technologies, Pipelining of FIR filters. Parallel processing of FIR filters. Pipelining and parallel processing for low power, Combining Pipelining and Parallel Processing.

Transformation Techniques: Iteration bound, Retiming, Unfolding, Folding and Folding of Multirate Systems.

Pipeline interleaving in digital filters. Pipelining and parallel processing for IIR filters and Higher order IIR filters, Low power IIR filter design using pipelining and parallel processing and Low Power Higher order filters, Pipelined adaptive digital filters.

Algorithms for fast convolution: Cook-Toom Algorithm, Winograd Algorithm, Iterative Convolution, Cyclic Convolution. Algorithmic strength reduction in filters and transforms: Parallel FIR Filters, DCT and inverse DCT, Parallel Architectures for Rank-Order Filters.

Synchronous pipelining and clocking styles, clock skew and clock distribution in bit level pipelined VLSI designs. Wave pipelining, constraint space diagram and degree of wave pipelining, Implementation of wave-pipelined systems, Asynchronous pipelining, Implementation of computational units using Asynchronous pipelining.

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Text Book

1. *K.K.Parhi, VLSI Digital Signal Processing Systems, John-Wiley, 2007.*

Reference Books

1. *U. Meyer -Baese, Digital Signal Processing with FPGAs, Springer, 2004*
2. *Wayne Burleson, Konstantinos Konstantinides, Teresa H. Meng, VLSI Signal Processing, 1996.*
3. *Richard J. Higgins, Digital signal processing in VLSI, 1990.*
4. *Sun Yuan Kung, Harper J. Whitehouse, VLSI and modern signal processing, 1985*
5. *Magdy A. Bayoumi, VLSI Design Methodologies for Digital Signal Processing, 2012*
6. Earl E. Swartzlander, VLSI signal processing systems, *1986.*

Course outcomes

At the end of the course student will be able

CO1: understand the overview of DSP concepts and design architectures for DSP algorithms.

CO2: improve the overall performance of DSP system through various transformation and optimization techniques.

CO3: perform pipelining and parallel processing on FIR and IIR systems to achieve high speed and low power.

CO4: optimize design in terms of computation complexity and speed.

CO5: understand clock based issues and design asynchronous and wave pipelined systems.

Course Code	**:**	**ECHO25**
Course Title	**:**	**LOW POWER VLSI CIRCUITS**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECPE31**
Course Type	**:**	**HO**

Course learning Objective

- To expose the students to the low voltage device modelling, low voltage, low power VLSI CMOS circuit design.

Course content

CMOS fabrication process, Shallow trench isolation. Lightly-doped drain. Buried channel. Fabrication process of BiCMOS and SOI CMOS technologies.

Modeling of CMOS devices parameters. Threshold voltage, Body effect, Short channel and Narrow channel effects, Electron temperature, MOS capacitance.

CMOS inverters, static logic circuits of CMOS, pass transistor, BiCMOS, SOI CMOS and low power CMOS techniques.

Basic concepts of dynamic logic circuits. Various problems associated with dynamic logic circuits. Differential, BiCMOS and low voltage dynamic logic circuits.

CMOS memory circuits, Decoders, sense amplifiers, SRAM architecture. Low voltage SRAM techniques.

Text Books

1. *Jan Rabaey,"Low Power Design Essentials (Integrated Circuits and Systems)", Springer,2009*
2. *J.B.Kuo&J.H.Lou,"Low-voltage CMOS VLSI Circuits", Wiley, 1999.*

Reference Book

3. *A.Bellaowar&M.I.Elmasry,"Low power Digital VLSI Design, Circuits and Systems", Kluwer, 1996.*
4. *Recent literature in Low Power VLSI Circuits.*

Course outcomes

At the end of the course student will be able

CO1: acquire the knowledge about various CMOS fabrication process and its modeling.
CO2: infer about the second order effects of MOS transistor characteristics.
CO3: analyze and implement various CMOS static logic circuits.
CO4: learn the design of various CMOS dynamic logic circuits.
CO5: learn the different types of memory circuits and their design.

Course Code	**:**	**ECHO26**
Course Title	**:**	**VLSI DIGITAL SIGNAL PROCESSING SYSTEMS**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECPC15 &ECPE31**
Course Type	**:**	**HO**

Course learning Objectives

- To enable students to design VLSI systems with high speed and low power.
- To encourage students to develop a working knowledge of the central ideas of implementation of DSP algorithm with optimized hardware.

Course content

An overview of DSP concepts, Representations of DSP algorithms. Systolic Architecture Design: FIR Systolic Array, Matrix-Matrix Multiplication, 2D Systolic Array Design. Digital Lattice Filter Structures: Schur Algorithm, Derivation of One-Multiplier Lattice Filter, Normalized Lattice Filter, Pipelining of Lattice Filter.

Scaling and Round off Noise - State variable description of digital filters, Scaling and Round off Noise computation, Round off Noise in Pipelined IIR Filters, Round off Noise Computation using state variable description, Slow-down, Retiming and Pipelining.

Bit level arithmetic Architectures- parallel multipliers, interleaved floor-plan and bit-plane-based digital filters, Bit serial multipliers, Bit serial filter design and implementation, Canonic signed digit arithmetic, Distributed arithmetic.

Redundant arithmetic -Redundant number representations, carry free radix-2 addition and subtraction, Hybrid radix-4 addition, Radix-2 hybrid redundant multiplication architectures, data format conversion, Redundant to Non redundant converter.

Numerical Strength Reduction – Sub expression Elimination, Multiple Constant Multiplication, Sub expression sharing in Digital Filters, Additive and Multiplicative Number Splitting.

Text Book

1. *K.K.Parhi, "VLSI Digital Signal Processing Systems", John-Wiley, 2007*

Reference Book

1. *U. Meyer -Baese, Digital Signal Processing with FPGAs, Springer, 2004*
2. *Recent literature in VLSI Digital Signal Processing Systems.*

Course outcomes

At the end of the course student will be able

CO1: Acquire the knowledge of round off noise computation and numerical strength reduction.

CO2: Ability to design Bit level and redundant arithmetic Architectures.

Course Code	**:**	**ECHO27**
Course Title	**:**	**ASYNCHRONOUS SYSTEM DESIGN**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**ECPC14**
Course Type	**:**	**HO**

Course learning Objectives

- This subject introduces the fundamentals and performance of Asynchronous system
- To familiarize the dependency graphical analysis of signal transmission graphs
- To learn software languages and its syntax and operations for implementing Asynchronous Designs

Course content

Fundamentals: Handshake protocols, Muller C-element, Muller pipeline, Circuit implementation styles, theory. Static data-flow structures: Pipelines and rings, Building blocks, examples

Performance: A quantitative view of performance, quantifying performance, Dependency graphic analysis. Handshake circuit implementation: Fork, join, and merge, Functional blocks, mutual exclusion, arbitration and Metastability.

Speed-independent control circuits: Signal Transition graphs, Basic Synthesis Procedure, Implementation using state-holding gates, Summary of the synthesis Process, Design examples using Petrify. Advanced 4- phase bundled data protocols and circuits: Channels and protocols, Static type checking, more advanced latch control circuits.

High-level languages and tools: Concurrency and message passing in CSP, Tangram program examples, Tangram syntax-directed compilation, Martin's translation process, Using VHDL for Asynchronous Design. An Introduction to Balsa: Basic concepts, Tool set and design flow, Ancillary Balsa Tools

The Balsa language: Data types, Control flow and commands, Binary/Unary operators, Program structure. Building library Components: Parameterized descriptions, Recursive definitions. A simple DMA controller: Global Registers, Channel Registers, DMA control structure, The Balsa description.

Text Books

1. *Asynchronous Circuit Design- Chris. J. Myers, John Wiley &Sons, 2001.*
2. *Handshake Circuits An Asynchronous architecture for VLSI programming – Kees Van Berkel Cambridge University Press,2004*

Reference Book

1. *Principles of Asynchronous Circuit Design-Jens Sparso, Steve Furber, Kluver Academic Publishers, 2001.*
2. *Asynchronous Sequential Machine Design and Analysis, Richard F. Tinder,2009*
3. *A Designer's Guide to Asynchronous VLSI, Peter A. Beerel, Recep O. Ozdag, Marcos Ferretti,2010*
4. *Recent literature in Asynchronous System Design.*

Course outcomes

At the end of the course student will be able

CO1: understand the fundamentals of Asynchronous protocols
CO2: analyze the performance of Asynchronous System and implement handshake circuits
CO3: understand the various control circuits and Asynchronous system modules
CO4: gain the experience in using high level languages and tools for Asynchronous Design
CO5: learn commands and control flow of Balsa language for implementing Asynchronous Designs

Course Code	**:**	**ECHO28**
Course Title	**:**	**PHYSICAL DESIGN AUTOMATION**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**HO**

Course learning Objectives

- Understand the concepts of Physical Design Process such as partitioning, Floor planning, Placement and Routing.
- Discuss the concepts of design optimization algorithms and their application to physical design automation.
- Understand the concepts of simulation and synthesis in VLSI Design Automation
- Formulate CAD design problems using algorithmic methods

Course content

VLSI design automation tools**-** algorithms and system design. Structural and logic design. Transistor level design. Layout design. Verification methods. Design management tools.

Layout compaction, placement and routing. Design rules, symbolic layout. Applications of compaction. Formulation methods. Algorithms for constrained graph compaction. Circuit representation. Wire length estimation. Placement algorithms. Partitioning algorithms.

Floor planning and routing- floor planning concepts. Shape functions and floor planning sizing. Local routing. Area routing. Channel routing, global routing and its algorithms.

Simulation and logic synthesis- gate level and switch level modeling and simulation. Introduction to combinational logic synthesis. ROBDD principles, implementation, construction and manipulation. Two level logic synthesis.

High-level synthesis- hardware model for high level synthesis. Internal representation of input algorithms. Allocation, assignment and scheduling. Scheduling algorithms. Aspects of assignment. High level transformations.

Text Books

1. *S.H. Gerez, "Algorithms for VLSI Design Automation", JohnWiley, 1998.*
2. *N.A.Sherwani, "Algorithms for VLSI Physical Design Automation", (3/e),Kluwer, 1999.*

Reference Books

1. *S.M. Sait, H. Youssef, "VLSI Physical Design Automation", World scientific,1999.*
2. *M.Sarrafzadeh, "Introduction to VLSI Physical Design", McGraw Hill (IE),1996.*
3. *Recent literature in Physical Design Automation.*

Course outcomes

At the end of the course student will be able

CO1: know how to place the blocks and how to partition the blocks while for designing the layout for IC.
CO2: solve the performance issues in circuit layout.
CO3: analyze physical design problems and Employ appropriate automation algorithms for partitioning, floor planning, placement and routing
CO4: decompose large mapping problem into pieces, including logic optimization with partitioning, placement and routing
CO5: analyze circuits using both analytical and CAD tools

Course Code	**:**	**ECHO29**
Course Title	**:**	**MIXED - SIGNAL CIRCUIT DESIGN**
Number of Credits		**3**
Prerequisites (Course code)	**:**	**NONE**
Course Type	**:**	**HO**

Course learning Objective

- To make the students to understand the design and performance measures concept of mixed signal circuit.

Course content

Concepts of Mixed-Signal Design and Performance Measures. Fundamentals of Data Converters. Nyquist Rate Converters and Over sampling Converters.

Design methodology for mixed signal IC design using gm/Id concept.

Design of Current mirrors. References. Comparators and Operational Amplifiers.

CMOS Digital Circuits Design: Design of MOSFET Switches and Switched-Capacitor Circuits, Layout Considerations.

Design of frequency and Q tunable continuous time filters.

Text Books

1. *R. Jacob Baker, Harry W. Li, David E. Boyce, CMOS, Circuit Design, Layout, and Simulation, Wiley-IEEE Press,1998*
2. *David A. Johns and Ken Martin, Analog Integrated Circuit Design, John Wiley and Sons,1997.*

Course outcomes

At the end of the course student will be able

CO1: Appreciate the fundamentals of data converters and also optimized their performances.
CO2: Understand the design methodology for mixed signal IC design using gm/Id concept.
CO3: Analyze the design of current mirrors and operational amplifiers
CO4: Design the CMOS digital circuits and implement its layout.
CO5: design the frequency and Q tunable time domain filters.

Course Code	**:**	**ECHO30**
Course Title	**:**	**DIGITAL SIGNAL PROCESSING FOR MEDICAL IMAGING**
Number of Credits		**4**
Prerequisites (Course code)	**:**	**ECPC15**
Course Type	**:**	**HO**

Course content:

Sources of Medical Images: Physics of X-ray, CT, PET, MRI, and ultrasound, advantages and disadvantages of each imaging modality.

Image Enhancement: Contrast adjustment, denoising (convolution, FFT), deblurring (solving an ill-conditioned sparse linear system), edge detection (numerical approximation to a partial derivative), anisotropic diffusion (numerical solution of partial differential equations), super-resolution.

Registration: Intensity-based methods, including a variety of cost functions (correlation, least squares, mutual information, robust estimators), and optimization techniques (fixed-point iteration, gradient descent, etc.). Implement registration for rigid and non-rigid transformations. MRI motion compensation.

Segmentation & tissue classification: Thresholding, region growing and watershed. More depth on the method of snakes (adaptive mesh), level set method (numerical solution of partial differential equations), and clustering (classifiers).

Reconstruction Methods: Reconstruction techniques for CT (filtered back projection) and MRI (using the FFT). Theory of the Radon transform, the Fourier transform, and how they relate to each other.

Text Books

1. *Jerry L. Prince, Jonathan M. Links, Medical imaging signals and systems, Pearson education, second edition, 2014*
2. *Mark. A. Haidekkar, Medical Imaging technology, Springer briefs in physics,2013.*

Reference Books

1. *Paul suetens, Fundamentals of medical imaging, second edition, Cambridge university press, 2009.*
2. *Recent literature in Digital Signal Processing for Medical Imaging.*
3. *Geoff Dougherty, Digital image processing for medical applications, Cambridge press*

Course outcomes

At the end of the course student will be able

CO1: Describe about different medical imaging modalities and its advantages and disadvantages
CO2: Describe the signal processing techniques involved in medical image enhancement techniques
CO3: Describe the signal processing techniques involved in image registration
CO4: Describe the signal processing techniques involved in segmentation and classification
CO5: Describe the signal processing techniques involved in image reconstruction.

Course Code	**:**	**ECHO31**
Course Title	**:**	**Advanced Techniques for Wireless Reception**
Number of Credits	**:**	**3**
Course Type	**:**	**HO**

Course Objective

- To get an understanding of signal processing techniques for emerging wireless systems.

Course Content

Wireless signaling environment. Basic signal processing for wireless reception. Linear receivers for synchronous CDMA. Blind and group-blind multiuser detection methods. Performance issues.

Robust multiuser detection for non-Gaussian channels; asymptotic performance , implementation aspects.

Adaptive array processing in TDMA systems. Optimum space-time multiuser detection. Turbo multiuser detection for synchronous and turbo coded CDMA.

Narrowband interface suppression. Linear and nonlinear predictive techniques. Code- aided techniques. Performance comparison.

Signal Processing for wireless reception: Bayesian and sequential Montecarlo signal processing. Blind adaptive equalization of MIMO channels .Signal processing for fading channels. Coherent detection based on the EM algorithm. Decision-feedback differential detection. Signal processing for coded OFDM systems.

Text Books

1. *X.Wang & H.V.Poor, "Wireless Communication Systems", Pearson, 2004.*
2. *R.Janaswamy, "Radio Wave Propagation and Smart Antennas for Wireless Communication", Kluwer, 2001.*

Reference Books

1. *M.Ibnkahla, "Signal Processing for Mobile Communications", CRC Press, 2005.*
2. *A.V.H. Sheikh, "Wireless Communications Theory & Techniques", Kluwer Academic Publications, 2004.*
3. *A.Paulraj ,Arogyaswami, R. Nabar, and D.Gore, "Introduction to Space-time Wireless Communications", Cambridge University Press, 2003.*
4. *Recent literature in Advanced Techniques for Wireless Reception.*

Course Outcomes
Students are able to

CO1: discuss the Wireless signaling environment and Performance issues.
CO2: analyze the channel modeling and multiuser detection.
CO3: analyze the Adaptive array processing and turbo coded CDMA.
CO4: analyze Linear and nonlinear predictive techniques.
CO5: analyze the Signal Processing Techniques for wireless reception.

Course Code	**:**	**ECHO32**
Course Title	**:**	**Error Control Coding**
Number of Credits	**:**	**3**
Course Type	**:**	**HO**

Course Objective

- To explain the importance of modern coding techniques in the design of digital communication systems.

Course Content

Review of modern algebra. Galois fields. Linear block codes; encoding and decoding. Cyclic codes. Non-binary codes.

Convolutional codes. Generator sequences. Structural properties. ML decoding. Viterbi decoding. Sequential decoding.

Modulation codes. Trellis coded modulation. Lattice type Trellis codes. Geometrically uniform trellis codes. Decoding of modulation codes.

Turbo codes. Turbo decoder. Interleaver. Turbo decoder. MAP and log MAP decoders. Iterative turbo decoding. Optimum decoding of turbo codes.

Space-time codes. MIMO systems. Space-time codes. MIMO systems. Space-time block codes (STBC) – decoding of STBC.

Text Books

1. *S.Lin & D.J.Costello, "Error Control Coding (2/e)", Pearson, 2005.*
2. *B.Vucetic & J.Yuan, "Turbo codes", Kluwer, 2000*

Reference Books

1. *C.B.Schlegel & L.C.Perez, "Trellis and Turbo Coding", Wiley,2004.*
2. *B.Vucetic & J.yuan, "Space-Time Coding", Wiley, 2003.*
3. *R.Johannaesson & K.S.Zigangirov, "Fundamentals of Convolutional Coding", Universities Press, 2001.*
4. *Recent literature in Error Control Coding.*

Course Outcome
Students are able to

CO1: understand the need for error correcting codes in data communication and storage systems.
CO2: identify the major classes of error detecting and error correcting codes and how they are used in practice. Construct codes capable of correcting a specified number of errors.
CO3: use the mathematical tools for designing error correcting codes, including finite fields.
CO4: explain the operating principles of block codes, cyclic codes, convolution codes, modulation codes, Turbo codes etc.
CO5: design an error correcting code for a given application.

Course Code	**:**	**ECHO33**
Course Title	**:**	**Digital Communication Receivers**
Number of Credits	**:**	**3**
Course Type	**:**	**HO**

Course Objective

- To expose the students to the latest trends in the design of digital communication receivers with particular emphasis on synchronization, channel estimation and signal processing aspects.

Course Content

Baseband PAM. Clock recovery circuits. Error tracking and spectral – line generating synchronizers. Squaring and Mueller and Muller synchronizers.

Channel models. Receivers for PAM. Optimum ML receivers. Synchronized detection. Digital matched filter.

ML synchronization algorithms – DD and NDA. Timing parameter and carrier phase estimation – DD and NDA.

Performance analysis of carrier and symbol synchronizers. Feedback and feed forward synchronizers. Cycle slipping Acquisition of carrier phase and symbol timing.

Fading channels. Statistical characterization. Flat and frequency selective fading channels. Optimal receivers for data detection and synchronization parameter estimation. Realizable receiver structures for synchronized detection.

Text Books

1. *H.Meyer , M. Moeneclaey, and S. A. Fechtel, "Digital Communication Receivers", Wiley, 1998.*
2. *U.Mengali & A.N.D.Andrea, "Synchronization Techniques for Digital Receivers", Kluwer , 1997.*

Reference Books

1. *N.Benuveruto & G.Cherubini, "Algorithms for Communication Systems and their Applications", Wiley, 2002.*
2. *H.Meyer & G.Ascheid, "Synchronization in Digital Communications", John Wiley, 1990.*
3. *Recent literature in Digital Communication Receivers.*

Course Outcomes

Students are able to

CO1: summarize baseband PAM and Synchronizers.
CO2: model and distinguish the channels.
CO3: interpret optimum receivers and matched filter receivers.
CO4: summarize phase and carrier estimation methods.
CO5: compare carrier and symbol synchronizers.

Course Code	**:**	**ECHO34**
Course Title	**:**	**ADVANCED DIGITAL SIGNAL PROCESSING**
Number of Credits		**4**
Prerequisites (Course code)	**:**	**ECPC15**
Course Type	**:**	**HO**

Course learning Objective

- To provide rigorous foundations in discrete-time stochastic process, optimum filter, adaptive filter, power spectrum estimation and frequency estimation.

Course content

Discrete-Time Random Process : Random Process: Ensemble average, Gaussian processes, Stationary process, autocovariance and autocorrelation matrices, ergodicity, white noise, power spectrum. Filtering random processes. Spectral factorization. ARMA, AR and MA processes. Harmonic processes. Linear mean square estimation. Parameter estimation Bias and consistency.

Optimum Linear filter and linear prediction : FIR Wiener filter. Orthogonality principle in linear mean square estimation. IIR Wiener filter: Non-causal Wiener filter and causal Wiener filter. Linear prediction. Forward and backward linear prediction. Levinson-Durbin algorithm.

Adaptive Filters : Adaptive filters. FIR adaptive filter. The steepest decent adaptive filter. LMS algorithm. Convergence of adaptive algorithms. Normalized LMS algorithm. Adaptive noise cancellation. Exponentially weighted RLS algorithm

Power Spectrum Estimation: Spectrum estimation. Estimation of autocorrelation. Periodogram method. Performance of the periodogram. Nonparametric methods: Bartlett's method, Welch method and Blackman-Tukey method. Performance comparisons. Minimum variance spectrum estimation. Parametric methods: AR spectrum estimation. Model parameter-Yule Walker equations.

Frequency Estimation: Eigen analysis of autocorrelation matrix. Pisarenko Harmonic Decomposition. MUSIC method. ESPRIT method. Minimum variance frequency estimation. Propagator method.

Text Books

1. *M.H.Hayes," Statistical Digital Signal Processing and Modeling", John-Wiley, 2001.*
2. *S.Haykin, "Adaptive Filter Theory (4/e)", Prentice- Hall, 2002.*

Reference Books

1. *D.G.Manolakis, V. K. Ingle, and S. M. Kogon ,"Statistical and Adaptive Signal Processing", McGraw-Hill,2005*
2. *S.L.Marple,"Digital Spectral Analysis", 1987.*
3. *Recent literature in Advanced Digital Signal Processing.*

Course outcomes

At the end of the course student will be able

CO1: To understand and analyze discrete-time random processes and employ the concept of stochastic processes to analyses linear systems

CO2: To select linear filtering and prediction techniques to engineering problems.

CO3: To describe the most important adaptive filter generic problems and various adaptive filter algorithms.

CO4: To derive and analyses the statistical properties of the conventional spectral estimators, nonparametric and parametric estimation method.

CO5: To select an appropriate array processing algorithm for frequency estimation

Course Code	**:**	**ECHO35**
Course Title	**:**	**Photonic Integrated Circuits**
Number of Credits	**:**	**3**
Course Type	**:**	**HO**

COURSE LEARNING OBJECTIVES

- The photonic integrated circuits course will introduce the basics of integrated optical waveguides used in optical communication applications.
- To introduce the concept reconfigurable architecture design in Photonic circuits
- To understand and realize Application-Specific Photonic Integrated Circuits and devices for Classical Applications
- This course also covers materials and fabrication technology for optical integrated circuits.

COURSE CONTENT

Brief history of optical communication, Advantages of integrated optics configuration, Guided TE and TM Modes of Symmetric and anti-symmetric planar waveguides: Step-index and graded-index waveguides. Strip and channel waveguides, Beam propagation method.

Directional couplers, Applications as power splitters, Y-junction, optical switch; modulators, filters, A/D converters, Mode splitters, Mach-Zehnder interferometer based devices.

Acousto-optic waveguide devices. Arrayed waveguide devices, Nano-photonic-devices: Metal/dielectric plasmonic waveguides, Surface Plasmon modes, applications in waveguide polarizers.

Materials. Glass, lithium niobate, silicon, compound semiconductors. Fabrication of integrated optical waveguides and devices. Lithography, deposition.

Waveguide characterisation, prism coupling, grating and tapered couplers, Nonlinear effects in integrated optical waveguides, Types and Applications.

Text Books

7. *H Nishihara, M Haruna and T Suhara, Optical Integrated Circuits; McGraw-Hill Book Company, New York, 1989.*
8. *C. R. Pollock and M Lipson, Integrated photonics, Kluwer Pub, 2003.*
9. *José Capmany and Daniel Pérez, Photonic Integrated Circuits, Oxford Univversity Press, 2020*

Reference Books

11. *A Ghatak and K Thyagarajan, Optical Electronics, Cambridge University Press, 1989.*
12. *T. Tamir, Guided wave opto-electronics, Springer Verilag, 1990*
13. *K. Okamota, Fundamentals of Optical waveguides, Academic Press, 2006.*
14. *T. Tamir, Integrated Optics, Springer Verlag, New York, 1982.*
15. *Recent journals and conference proceedings.*

Course outcomes

At the end of the course student will be able

CO1: Summarize the fundamental concept of optical waveguides.

CO2: Construct the different types of optical waveguides.

CO3: Construct the couplers, modulators and devices for communication applications

CO4: Summarize fabrication technologies for design of optical waveguides

CO5: Describe the various nonlinear effects in integrated optical waveguides.

Course Code	**:**	**ECHO36**
Course Title	**:**	**Microwave Circuits**
Number of Credits	**:**	**3**
Course Type	**:**	**HO**

COURSE OBJECTIVE

• To make the students familiarize with ABCD parameters, S parameters, Applications of planar transmission lines in the practical microwave circuits, Design and layout of all Microwave Integrated Circuit Design components and then systems.

COURSE CONTENT

Introduction and application of microwave circuits - Two-port network characterization. ABCD parameters, Conversion of S matrix in terms of ABCD matrix. Scattering matrix representation of microwave components. Review of Smith chart and its application- Impedance matching using Lumped and Distributed approach.

Microwave Passive circuit design: Characteristics, properties, design parameters and applications-Design and realization of MIC Power dividers. 3 dB hybrid design. Directional Coupler design-Hybrid ring design.

Microwave filter design- Filter design by insertion loss method –Richards and Kuroda transformation. K inverter, J inverter. Resonator filters. Realization using microstrip lines and strip lines.

Microwave amplifier design- Power gain equations -Stability considerations. Maximum gain design, Design for specific gain -Low Noise Amplifier Design. High power design.

Microwave oscillator design. One – port and two – port negative resistance oscillators and oscillator design

Text Books:

1. *Reinhold Ludwig, RF circuit design, 2nd edition, Prentice Hall 2014, ISBN: 978-0131471375*
2. *David. M. Pozar, Microwave engineering, 4th edition, John Wiley, 2011, ISBN: 978-0470631553.*
3. *Devendra K. Misra, "Radio-Frequency and microwave communication circuits analysis and design", 2nd edition, University of Wisconsin-Mulwaukee, A John Wiley & Sons Publication*

Reference Books:

1. *B. Bhat, S. K Koul, "Stripline like transmission lines for Microwave Integrated Circuits", New Age International Pvt. Ltd Publishers, 2007.*
2. *I.J.Bahl & P.Bhartia, "Microwave Solid state Circuit Design (2/e)", Wiley, 2003.*
3. *Matthew M. Radmanesh, Radio Frequency and Microwave Electronics Illustrated, Prentice Hall, 2012*
4. *S.Y.Liao, "Microwave Circuit Analysis and Amplifier Design", Prentice-Hall, 1986.*
5. *G. Mathaei, L young, E.M.T. Jones, "Microwave filters, Impedance-Matching networks and Coupling structures", Artech House Books.*

COURSE OUTCOMES

Students are able to

CO1: Understand the basics of Scattering matrix and two port characterization and importance of matching circuits.

CO2: Analyze the working principles of couplers, power dividers etc. and their design.

CO3: Design the different types of MIC filters and their implementation.

CO4: Understand the complexities of microwave amplifier design and its stability features.

CO5: Analyze and appreciate the design principles of microwave oscillators.